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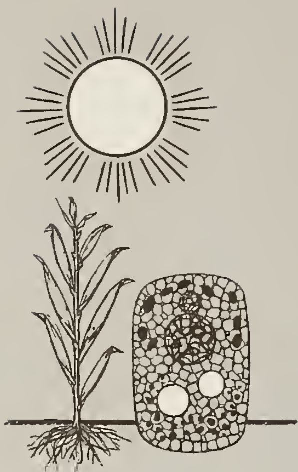
PLUM ISLAND LABORATORY: Its Role In Foreign Animal Disease Research Page 1



AGRICULTURAL SCIENCE REVIEW

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Operation Alert!

It may surprise some of our readers to learn of the elaborate preparedness plan the United States has set up to cope with the next outbreak of foot-and-mouth disease in this country—if it occurs. Naturally, everyone hopes we'll never have to use that plan. But as each year passes and no new outbreak occurs—it's been 42 years since the last one—the need for vigilance rises. Such reasoning is based on a simple biological fact.

Animals have been enduring disease-causing organisms for millions of years, and in most cases they learn to live with them, so to speak, under tolerable levels of species decimation. It's a different and tragic story, however, when a massive invasion of unfamiliar micro-organisms comes along. Lack of natural restraints can permit these organisms to run rampant.

A couple of interesting parallels can be cited among human populations. The U.S. Public Health Service points out that 85 percent of the Americans who visit Mexico come down with a bout of "turista"—an intestinal disorder caused by unfamiliar organisms in food or water. Yet very few, if any, Europeans visiting Mexico have this problem, presumably because their bodies had become accustomed to these organisms in their native land.

In the 1950's, the only serious polio epidemics occurred in countries that were enjoying a high degree of protection from germs—the United States and Scandinavia. Other examples could probably be cited among both humans and domestic animals.

Thus, the longer our livestock remain unexposed to foot-and-mouth viruses, the greater our potential losses from a future outbreak. Note, however, that we said *potential* losses. We'd like to think that our research and regulatory activities will be the means for keeping foot-and-mouth disease forever in limbo.

In the meantime, those in charge of our preparedness plan will have to keep booted and spurred—no matter how dull and lonely the waiting may be.—W.W.K.

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PLUM ISLAND LABORATORY

Its Role In Foreign Animal Disease Research

J. J. CALLIS

UNTIL recent times, the chances of exotic, or foreign, animal diseases being introduced into the United States have been minimal. In the pre-jet age, livestock movements from one country to another were not only fewer but slower. Thus, the days or weeks required for shipment served as an effective quarantine period during which animals showing signs of disease could be disposed of or their entry prevented.

Now, however, the rising demand for animal protein and modern methods of international transportation have markedly increased the volume of trade in livestock and animal products. At the same time, the more rapid movement of such products in effect has removed some of the natural barriers we formerly had for limiting the importation of new diseases. Rising populations of people and animals, along with the increased mobility of both, have stepped up the chances for the rapid and international spread of the "emerging diseases."

Another element that heightens the threat of foreign animal diseases becoming established in this country is the fact that our native populations are much more susceptible to a disease for which they have no past history of immunity or resistance.

In addition, travelers may ignorantly or illicitly carry with them items of food and plants that are hosts to disease organisms, some of which may be etiological agents of serious diseases of domestic animals.

All of these factors combine to make the threat of an outbreak of foreign animal disease in the United States something to be guarded against with every means available by public and private interests alike. The program demands the utmost cooperation in education, regulatory activities, and research. Because each phase of this program is really a story in itself, this paper deals with only one of them—that of the research efforts of the U.S. Department of Agriculture, which are conducted primarily at the Plum Island Animal Disease Laboratory.

EARLY RESEARCH EFFORTS

RESEARCH efforts on the diagnosis, treatment, and eradication or control of foreign animal diseases—in effect for *all* animal diseases—began in 1883 with the establishment of the Veterinary Division of the U.S. Department of Agriculture. The situation that had prompted this act was the rather widespread prevalence of contagious pleuropneumonia in cattle (dating from 1843 when a cow imported from Britain was found to have the disease),

hog cholera, cattle tick fever, anthrax, blackleg, brucellosis, and other diseases. Some of these diseases had developed to the extent that other countries were refusing to import our meat and meat products.

Further assistance came in 1884 when Congress passed an act for the establishment of the Bureau of Animal Industry to "prevent the exportation of diseased cattle, and to provide the means for the suppression and extirpation of pleuropneumonia and other contagious diseases among domestic animals."

After 5 years of work and the expenditure of $1.5 million, the United States became the first country to wipe out contagious pleuropneumonia. One of the important lessons learned in this eradication campaign was that any degree of security from a contagious disease can come only through the combined efforts of State, national, and international authorities, and the affected community or producing area itself.

The second research challenge the Bureau of Animal Industry took on was to find the cause of tick fever, which presumably had entered this country in the early 17th century from the West Indies and Mexico. By the 1860's, cattle movements from Texas had spread the disease into the Midwest. In 1889 the disease was found to be caused by a protozoan parasite in the blood of infected animals, and in 1892 the first bulletin of the Bureau announced that the infection could be carried from one animal to another by an intermediate host—the tick. Research on a suitable means of destroying the tick continued for more than a decade, and finally in 1911 a government order established the use of an arsenical solution as an official dip for interstate movement of cattle from quarantined areas. Despite some opposition to this method of controlling the tick, dipping schedules were maintained and tick fever eventually ceased to be a significant disease in the United States.

These two classic examples of successful research effort set the pattern for research and eradication programs for other disease problems as they arose. In many cases, the incidence of a disease has been lowered to the point where it no longer poses much of a threat to agriculture. Some diseases, however, still cause tremendous losses and therefore require continued research study, vigilance, and cooperative action to bring them under control. Although losses from foreign animal diseases are minimal in comparison with those indigenous to the United States, these diseases can no longer be regarded as exotic curiosities because they are literally just hours from our shores. Diseases that are least familiar to us not only have the potential for gaining a quick foothold, but also can be the most devastating because of more readily susceptible hosts. It is for these reasons that the present research programs on foreign animal diseases—together with regulatory activities—have developed to the extent and scope under which they now operate.

DESCRIPTION AND HISTORY OF DISEASES

SOME of the diseases which plague man's livestock and fowl have been around for centuries, although in some cases they were either not specifically identified or called by another name. Many more, however, have a history of only a matter of decades; that is, the known cases of initial infection or outbreak have occurred rather recently. The research program at the Plum Island Animal Disease Laboratory encompasses most of the known diseases, and the degree of emphasis is generally in direct proportion to the economic significance of a particular disease.

Foot-and-Mouth Disease

FOOT-and-mouth disease (FMD) is an acute, highly communicable disease affecting cattle, swine, sheep, goats and other cloven-footed animals, both domestic and wild. It is characterized by vesicular lesions in the mucosa of the mouth and in the thin, hairless skin between and above the hoofs and on the teats and udder. Pathological changes in the body of an affected animal produce other signs, such as an increase in body temperature, loss of appetite, and profuse slobbering. Lameness is often evident and because chewing may be painful, the animal eats less or not at all and therefore loses weight and condition. Milk flow decreases or stops. Mastitis, abortion, and chronic deformities of the feet are rather common. Even though FMD spreads rapidly, the mortality in adult animals seldom exceeds 5 percent. In young animals, mortality may be as high as 50 percent. The greatest effect of the disease, therefore, is due more to body deterioration and loss of productivity rather than death.

FMD is caused by a filterable virus that is believed to be one of the smallest viruses that cause disease in animals—about 22 millimicrons. When an animal becomes infected, the virus spreads throughout the body, and all secretions and excretions including respired air contain the virus. The viability of the virus depends on the conditions under which it is harbored, but it has been known to remain virulent for months in previously contaminated areas, thereby facilitating its spread. Infected animals may excrete virus for up to 10 days before lesions appear. Recovered animals may still harbor the virus, although they show no signs of infection.

Early literature indicates that foot-and-mouth disease may have been affecting livestock since the 16th century. Documented evidence of a contagion in Italy in 1514 bears marked resemblance to the disease as we know it today. Since then, it has appeared in practically all parts of the world. It is now considered to be enzootic (generally present) in all the major livestock-producing countries except North America, Australia, and New Zealand.

Foot-and-mouth disease has been introduced into the United States and eradicated six times in this century, and three times prior to that. The first outbreak during this century was in 1902 and was confined to the New England States. The last outbreak occurred in 1929 in California and was introduced by ships' garbage. During the 1924 outbreak, the disease gained entry into the deer population in the Stanislaus National Forest in California. Some thought that the widespread infection in wildlife would make eradication impossible. It did pose a monumental problem, but the outbreak was contained in California and eradicated. More than 22,000 deer had to be destroyed.

The most extensive outbreak—in 1914—was first detected in the vicinity of Niles, Michigan. Unfortunately, the mild form and atypical appearance of the first cases permitted the disease to spread unrecognized to a considerable number of herds of cattle and hogs. Some of the latter reached and presumably infected the stockyards at Chicago. From Chicago, the infection was disseminated to other stockyards by shipments of livestock, especially stockers and feeders. Twenty-two States and the District of Columbia were infected before the disease could be eradicated.

The most recent outbreaks in other countries were as follows: Mexico, 1953–54; Canada, 1952; Great Britain, 1967–68; and Holland, 1968. The disease has never appeared in New Zealand, probably because of its geographical isolation and vigilance, and last appeared in Australia in 1872.

Control measures against foot-and-mouth disease vary in different countries; the type used depends on climate, degree of isolation, extent of production, the knowledge available, and the economy of the area.

In the United States, as in a number of countries where FMD is not enzootic, a Government-supervised quarantine is imposed as quickly as possible within and surrounding the affected area. Infected animals and all exposed susceptible livestock are slaughtered and buried on the premises. Afterwards, the premises are cleaned and disinfected, and after 30 days a few susceptible animals are placed on the farm by the Government. Thirty days later, if no symptoms appear, permission is granted to acquire new stock, but the farm is still considered under restrictions until a 90-day disease-free period has passed. Owners usually receive Government indemnity payments to cover the cost of animals and property destroyed during the eradication operation.

In countries where livestock are repeatedly exposed to the disease, outbreaks are usually controlled by quarantine and vaccination. Some countries vaccinate regularly; for example, in Holland, all cattle more than 4 months old are vaccinated annually.

Vaccination has not been used in the United States and Canada, because there is no point in vaccinating when the disease does not exist here. In a country where outbreaks are infrequent, eradication is less costly than mass vaccination.

African Swine Fever

AFRICAN swine fever (ASF) is an acute, highly contagious viral disease of swine. Native wild swine in Africa harbor the disease without apparent illness, but when the virus is transmitted to domestic swine, it causes an acute febrile disease characterized by temperatures of 104° to 108°F., marked hemorrhages in the internal organs, and gross lesions that closely resemble those of hog cholera. The pulse and respiration are accelerated, and if the animals are

forced to rise, they appear weak and uncoordinated. Vomiting, diarrhea, and discharges from the eyes may also occur. Death usually occurs by the seventh day after the onset of fever. Mortality frequently approaches 100 percent.

In areas where ASF has occurred over long periods in swine, the severity of the disease is somewhat lessened. The most likely mode of transmission from wild to domestic animals is by tick bite; thereafter it spreads by contact among the domestic herd.

It is not known how long ASF has existed in Africa, but the disease was first identified and described in 1910 in Kenya. From 1910 to 1912, 14 outbreaks involving about 1,300 swine were reported. Although outbreaks continued sporadically in various parts of sub-Saharan Africa, there was little concern for the disease until 1957 when it appeared in swine herds in Portugal. Outbreaks were reported in France in 1964 and Italy in 1967, but it now appears to have been eradicated from these countries. ASF is still causing heavy losses, however, in Spain and Portugal.

Worldwide concern for African swine fever has heightened considerably since severe outbreaks were reported in Cuba in mid-1971. At this writing the number of affected animals is not known, but it has been reported that at least 460,000 animals have been slaughtered in two provinces in an effort to eradicate and control the disease. The manner of entry is not known; however, ASF can be transmitted by contaminated garbage, feed, or water; contact between infected and susceptible hogs; and contaminated clothing and equipment.

Attempts to immunize swine against ASF have been unsuccessful. The chief control measure, therefore, is quarantine and eradication—somewhat the same as for foot-and-mouth disease.

Rinderpest

RINDERPEST is an acute, febrile, viral disease of ruminants, particularly cattle and buffalo. Clinical features include an abrupt rise in temperature, nasal discharges, hemorrhage, and erosion of the mucous membrances of the digestive tract. Temperature reaches its peak by the third to fifth day, and as the temperature drops diarrhea commonly starts. Death usually occurs from 6 to 12 days after the onset of the fever. Mortality is close to 100 percent.

Rinderpest is usually transmitted by direct contact between infected and susceptible ruminants, and the movement of infected animals is generally responsible for spread of the disease. There is no evidence that the disease is spread by insect vectors. Cattle that recover from rinderpest are not known to be carriers. In enzootic areas, native cattle seem to carry some resistance.

Test animals coming to Plum Island are first held in quarantine for 2 weeks in a former mortar installation (left), then taken up a ramp into the laboratory (center), where they pass through two air locks (right) before reaching their assigned quarters. Animals once taken inside this building are never allowed out again.

Records show that rinderpest is perhaps the most devastating disease of cattle—both from the standpoint of its persistence throughout history and the heavy toll it has taken. It has been estimated that in the 19th century rinderpest killed approximately 200 million cattle, and prior to 1949 the annual toll in the 20th century was 2 million cattle a year. Chief areas of infection are Africa, Middle East, Pakistan, India, Burma, and Southeast Asia. Except for parts of Turkey, Europe has been relatively free of the disease since 1930. Other than a mild outbreak in Brazil in 1921, North and South America have also remained free of rinderpest.

Once a herd becomes infected with rinderpest, the only effective control measure is quarantine and eradication. Clinical diagnosis has been complicated in recent years by the occurrence of a number of diseases of the alimentary mucosa of cattle which are similar clinically. These mucosal diseases have been reported in most cattle-producing areas of the world, including those where rinderpest is endemic. Because of this situation, the occurrence of a number of so-called mucosal diseases in the United States has caused some concern among animal health officials, lest these diseases may be due to an aberrant form of the rinderpest virus. Accurate and rapid diagnosis of all such diseases, therefore, is very important in maintaining control.

Development of an attenuated live virus vaccine in the late 1950's has provided the means for materially reducing the incidence of rinderpest through mass vaccination. In those countries where such vaccination programs have been carried out, few recent outbreaks have occurred. These efforts have been possible only through the assistance of various international organizations such as FAO of the United Nations, U.S. Agency for International Development, the European Economic Community, and others. Unfortunately, not all countries have cooperated and in these areas, rinderpest outbreaks continue.

Contagious Bovine Pleuropneumonia

CONTAGIOUS bovine pleuropneumonia (CBPP) is a highly infectious disease of cattle caused by a small bacterium, *Mycoplasma mycoides*. The disease develops with a sudden rise in temperature, cessation of rumination, and severe depression. As the disease progresses, other signs are shallow breathing, arched back and extended head and neck, and grunting respiration. Swelling of the throat and dewlap may occur. Although cases vary in severity, in acute cases, death usually occurs in 2 or 3 weeks. Mortality rates vary from 10 to 70 percent. The disease is transmitted by contact through inhalation of dispersed bronchial secretions. One of the difficulties in controlling CBPP is that recovered animals mav serve as carriers for as long as 3 years.

The disease has been known for more than 200 years in all parts of the world. In the early part of the 19th century, it became widespread in Europe, and from there it spread to South Africa, Australia, and the United States in exported cattle. Today, the western hemisphere, South Africa, Japan, and parts of Australia are considered to be free of the disease. CBPP is still a major obstacle to development of the cattle industry in parts of Africa and Asia.

Sanitation, disinfection, and vaccination are common practices in countries where the disease is enzootic. The slaughter policy is followed only in countries where outbreaks are scarce. As with rinderpest, cooperative campaigns under the aegis of the United Nations and other international organizations are showing success in lessening the incidence of CBPP.

Teschen Disease

TESCHEN disease is a contagious viral polioencephalomyelitis of swine. It is characterized by nervous disturbances, staggering gait, hyperesthesia, and leg paralysis. Death may follow 1 or 2 days after the onset of paralysis. Mortality rate is about 70 percent.

The disease was first recognized in 1929 in the Teschen district of the Czechoslovakian-Polish border. It now occurs in most southern European countries and the island of Madagascar. Germany and Yugoslavia are reportedly free of the disease.

Feces of affected animals are the most common source of Teschen disease virus, although rats have been incriminated. No satisfactory treatment for the disease is known. Control measures include sanitation, disinfection, and immediate slaughter and disposal of sick and exposed swine. Several enteroviruses isolated from swine in the United States are serologically related to Teschen virus, however, on cross-immunity studies, differences in the two viruses may be demonstrated.

Fowl Plague

FOWL plague is a highly contagious, usually fatal, viral disease of chickens and turkeys, although it may affect ducks, geese, and other fowl. Birds may die without any clinical signs, but the common signs are loss of appetite, ruffled feathers, staggering, cyanosis of comb and wattles, and loss of egg production. Sometimes blisters may appear on combs and wattles. Death usually occurs in 2 days. Mortality is near 100 percent.

The disease was diagnosed in Europe in the early 1900's and later was identified in some Asian and African countries. Argentina reported an outbreak in 1922, and outbreaks occurred in England and the United States in 1924. Losses from the latter one were extremely high. Lesser outbreaks occurred in Delaware and New Jersey in 1925 and 1929 respectively. England also reported two outbreaks in 1963.

Strict quarantine and complete destruction of all sick and exposed birds is the most effective means of eradicating the disease in areas previously unaffected. Generally, inactivated virus vaccines are ineffective; some experimental live virus vaccines show promise, however.

Other Diseases

THERE are more than 30 foreign animal diseases which are not present in the United States, but which pose a constant threat to our $20.6 billion livestock and poultry industries. Those discussed in the foregoing descriptions represent some of the more important ones on which the Plum Island Laboratory conducts research. Others are given in table 1. Diseases for which research programs have not been set up include those generally considered to be less of a threat to our country.

STAFF AND FACILITIES

PLUM Island Animal Disease Laboratory is situated on an 800-acre island about 1½ miles northeast of the eastern end of the north fork of Long Island. It is not open to the general public and can be reached only by marine craft operated by the Laboratory. Admittance is limited to employees, certain visiting scientists, those who have official business with the Laboratory, and staff of the U.S. Coast Guard who man the lighthouse at the western tip of the island. The Laboratory's geographical isolation and the strict visitor restrictions are necessary safety precautions to prevent the escape of the disease agents under study.

Of the Laboratory's 330 employees, approximately 10 percent are members of the research, diagnostic, and administrative staffs. Science disciplines represented in this group include veterinary science, virology, bacteriology, pathology, chemistry, and physics. The professional staff is supported by technicians, engineers, animal caretakers, maintenance crew, craftsmen, marine personnel, library and clerical staff, and safety and security staff including guards and firemen.

The two main buildings on Plum Island, which were specifically designed for research on highly communicable diseases, are considered among the safest in the world for work on animal viruses.

All entrances and exits for personnel, animals, and supplies are strictly controlled. Exhaust air from these buildings is decontaminated through a system of filters, and all liquid wastes are sterilized by heat before being discharged. Solid wastes—including animal carcasses—are destroyed by incineration within the research buildings.

Persons entering the research buildings must leave street clothing and personal belongings in outer locker rooms and use laboratory clothing while in the building. Upon leaving, each person must take a complete shower before putting on his street clothing.

All personnel of the laboratory are prohibited from contact with susceptible species of animals, or premises where such animals are held, for specified periods of time after leaving the island.

Other buildings making up the Laboratory complex include an administration building, three facilities for housing normal animals, various craft shops, powerplant, sewage decontamination building, warehouses, cafeteria, experimental animal colonies, assembly hall, and dock terminal. The Laboratory also maintains a mainland office at Orient Point for handling personnel and public relations matters and for the shipping and receiving of materials to the island.

Although most of the Laboratory's work is conducted during daylight hours, a small night shift is maintained to supervise certain operations and perform functions that must necessarily continue around the clock.

Plum Island

Plum Island was named by early explorers who observed beach plums growing along the shores. In 1659, the ruling Indian chief of Long Island sold Plum Island to the first European owner for a coat, a barrel of biscuits, and 100 fishhooks.

The U.S. Government bought the island in the 1890's and established Fort Terry, a coast artillery post. After World War II, the island was assigned to the Army Chemical Corps, and on July 1, 1954, the military formally transferred Plum Island to the U.S. Department of Agriculture.

Plum Gut, noted for its deep waters and dangerous tides and currents, separates the western end of the island and the Orient Point end of Long Island. On one occasion since the Laboratory was established, a severe coastal storm and hazardous crossing conditions forced employees to remain on the island all night. Fortunately, housing facilities, formerly used by the military, are available for use on such occasions.

Sport fishing is particularly good in the waters around the island, and occasionally when fishermen allow their boats to drift too close to shore, they must be warned by security guards—equipped with powerful bull horns—to stay clear.

DIAGNOSTIC AND SERVICE ROLE

APPROXIMATELY 30 percent of the activity and effort of the Plum Island Laboratory staff is devoted to diagnostic and service functions. To a large extent, these functions are a natural outgrowth of the research competency which the Laboratory has developed since its founding.

To date, diagnostic competency has been completed or partially completed for 17 foreign animal diseases and at least six additional ones are scheduled for study (table 1). One of the difficulties of correctly identifying a disease has been the lack of accurate tests to distinguish it from another disease which may present similar symptoms. African swine fever is a typical example, because its characteristics closely resemble those of hog cholera. Until recently, it was impossible to distinguish the two diseases either clinically or at necropsy. In 1958, however, W. A. Malmquist, working with the Department of Agriculture in Kenya, developed a method for differentiating the two diseases.

In this method, the ASF virus is propagated on buffy coat cells of swine. After infection, swine red blood cells adsorb to the periphery of those cells containing virus. This phenomenon is not observed in control cultures or in cultures inoculated with hog cholera virus. Until this test was developed, the only means available to differentiate ASF and hog cholera was by inoculation of normal swine and swine immune to hog cholera. When ASF virus is inoculated, all animals succumb—those immune to hog cholera as well as those fully susceptible. Obviously, such diagnostic procedures require time as well as animal facilities.

Diagnostic procedures for other diseases have been improved more or less in the same pattern as that for ASF, that is, to make them more sensitive, accurate, quicker, and as economical as possible.

The importance of diagnostic capability—and the resulting consequences when that capability does not exist—has been demonstrated in a number of cases in the United States. Bluetongue of sheep and Newcastle disease of poultry are typical examples. Be-

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TABLE 1.—*Record of diagnostic achievements at the Plum Island Animal Disease Laboratory*

Diagnostic competency completed or partially completed	Fowl plague Contagious bovine pleuropneumonia Contagious caprine pleuropneumonia Duck plague (duck virus enteritis) Sheep pox Rinderpest Teschen disease African swine fever African horsesickness Foot-and-mouth disease Vesicular exanthema of swine Bovine herpes virus (bovine herpes mammillitis virus) Ephemeral fever Newcastle disease—exotic strains Lumpy skin disease Goat pneumonitis Contagious agalactiae
Diseases yet to be studied	Louping ill Infectious petechial fever Nairobi sheep disease Sweating sickness Borna disease Equine encephalosis

cause few U.S. veterinarians were familiar with bluetongue, an outbreak around 1950 was unrecognized and became widely spread throughout the Southwest before it was correctly diagnosed in 1952. Newcastle disease of poultry reached the United States about 1940, but because of the atypical nature of the disease in California, it was not definitely diagnosed until 1944. By 1947 it had spread to virtually all States.

As a result of the competency in diagnosing exotic animal diseases among the Plum Island Laboratory staff, they are frequently called upon to perform emergency diagnostic services for State and Federal field veterinarians who have encountered a disease with which they are unfamiliar or which they suspect may be in the exotic class. The Laboratory accepts tissue or blood samples which are promptly analyzed, and the results of the diagnosis are in turn relayed to the field. If the diagnosis reveals that the suspected disease is an exotic one, further follow-up service may include field surveillance of the suspected herd or area of incidence and assistance in eradicating the outbreak. The number of requests for diagnostic assistance has increased steadily since the Laboratory began operation, which indicates that veterinarians in the field are more mindful of the possibilities of an exotic animal disease having been introduced. This is considered to be a healthy turn of events.

Evidence of the benefits likely to accrue from such service functions may be illustrated by the ensuing events following an outbreak of duck plague (duck virus enteritis) on Long Island in 1967. After the diagnosis was confirmed, a survey was made of ducks in other areas of the United States, including wildfowl. Since the disease was present in the wildfowl, it was determined that they would serve as a continuing source of the disease and hence pose a continual threat to domestic flocks. It was decided, therefore, that the disease could best be checked and

perhaps eliminated by use of a vaccine which initially was imported from Holland. Continued use of the vaccine on Long Island flocks has brought the disease under control in commercial flocks.

A somewhat similar incident occurred in Minnesota when a field veterinarian submitted tissue samples from a cow which he suspected had lumpy skin disease. About 1,000 cattle in that area were tested, and the disease was eventually diagnosed as being a virus disease similar to bovine herpes mammillitis, which had previously been described in Great Britain. More recently, cattle serums from Virginia and Iowa have been examined for antibodies against bovine herpes mammillitis virus, and as a result of this study it has been determined that the disease is widespread and has probably existed in the country for a long time. Fortunately, it is not a severe disease and economic losses occur principally only when the disease occurs in dairy animals and when the infection causes sores on the udder and teats.

An increasingly important service function of the Plum Island Laboratory is that of training offered for field veterinarians of USDA's Animal Health Division. Two training sessions have already been held this year—one in January and one in September, and future schedules will be set according to the demand and need. About 12 trainees are accepted for each session which runs for 50 hours or more. The course offers both lectures and animal room study on 8 or 10 diseases of foreign origin—principally those of greatest economic impact—and includes history, distribution, symptoms, and means of differentiation from domestic diseases.

Additional services provided by the Laboratory include examination of semen samples imported from foreign countries for artificial insemination and of specimens from quarantined live animals prior to importation. The Laboratory is also called upon occasionally to give advice to animal health authorities on the likelihood of virus survival in variously treated food and biological products offered for importation, and on the efficacy of disinfectants used in aircraft, ships, and other equipment used for animals and animal products.

THE RESEARCH ROLE

THE research programs at Plum Island Laboratory have roots that can be traced back to a number of situations and events long before its establishment. Throughout all of them runs a common thread of concern for one particular malady—the dreaded foot-and-mouth disease. Actually, it may be said that the effects of nine previous outbreaks of FMD and the constant threat of future outbreaks were largely responsible for the founding of the Laboratory.

Although interest in FMD dates from 1870—the year of the first U.S. outbreak—the first real efforts of the Department of Agriculture to acquire more knowledge about the disease commenced in 1924. Consequences of the outbreaks in California and Texas led to the establishment of a Foot-and-Mouth Disease Commission, which carried on research in Europe in 1925 and 1926. The reason for the choice of a foreign site was that existing regulations prohibited experimentation with FMD virus in the United States.

Following the 1946 Mexican outbreak of FMD, the Department's Foot-and-Mouth Disease Advisory Committee recommended in 1947 that further research be initiated in cooperation with European laboratories to help the Mexico-United States FMD Commission and to strengthen protection against the disease in the United States. This cooperative work began in 1948 and certain aspects of it still continue.

In the meantime, the Congress had earlier passed the 1930 Smoot-Hawley Tariff Act which, among other things, prohibited the importation of susceptible livestock, fresh meat, and animal products from countries where FMD and rinderpest exist.

Believing that the cooperative research abroad was not enough, the FMD Advisory Committee further recommended that research facilities be constructed in the United States as soon as possible. This recommendation, together with the impact of the Mexican outbreak which was still continuing, resulted in the 80th Congress passing Public Law 496. The law required that a laboratory and related research facilities be established on a coastal island surrounded by deep and navigable waters. Research was authorized on foot-and-mouth disease and "such other animal diseases as, in the opinion of the Secretary of Agriculture, might constitute a threat to the livestock industry of the United States."

It was not until 4 years later, however, in 1952, that action came to implement Public Law 496. Undoubtedly influenced by a new outbreak of FMD just across the U.S.-Canadian border in Saskatch-

ewan, the Congress appropriated $10 million for constructing a laboratory. The site selected was Plum Island, N.Y., which at that time was occupied by the Army's Fort Terry. Evacuation of the military was completed 2 years later, and on July 1, 1954, the island was formally transferred to the Department of Agriculture and limited research began.

Research activity at Plum Island constitutes approximately 70 percent of total staff effort. Since the Laboratory was established 17 years ago, projects related to foot-and-mouth disease have traditionally outnumbered those of other diseases. Current emphasis on the basis of the percentage of total scientist-man-years devoted to a particular disease is as follows: foot-and-mouth disease, 54 percent; African swine fever, 11 percent; contagious bovine pleuropneumonia, 6 percent; and the remainder is related to diagnostic services or study. In this area, the Laboratory develops versatility and capability among research personnel to diagnose 32 or more foreign animal diseases. Methods of diagnosing are constantly being updated, and reference reagents are being produced and maintained.

Specific disease-related research work is organized more or less along four science discipline lines—microbiological, cytological, biochemical and physical, and immunological. This organizational method gives the advantage of an interdisciplinary approach toward the research problems associated with any one particular disease. Discussion of these areas in this review will concentrate largely on the FMD research—in keeping with the accompanying degree of research emphasis on that disease.

Microbiological

MICROBIOLOGICAL investigations deal essentially with the role of the carrier, that is, the host animal, in (a) the spread of the virus, (b) the susceptibility of various species of animals, and (c) the survival of virus in meat and other animal products and outside the animal.

Considerable work has been done at the Laboratory on the latency of the FMD virus. About 90 percent of the cattle that recover from FMD will carry the virus—some for as long as 2 years. This poses the problem as to the role of the carrier animal in the perpetuation of the disease. The fact that it has been impossible to transmit FMD experimentally from carriers to susceptible cattle indicates the existence of unknown factors in either the recipient or the donor which influence transmission. Furthermore, vaccinated animals have been known to pick up the virus from infected cattle and yet not transmit it.

Because vaccination is widely used in some countries, and because it may find wider use elsewhere and in the future, the Laboratory is now investigating the development and importance of FMD virus carriers in connection with vaccination programs. Both vaccinated and nonvaccinated animals are being exposed to the virus, and then examined for percentage of carriers produced, virus yields, duration of carrier state, and antibody production. To date, an agar gel diffusion precipitin test has proved useful for surveys of animal populations to detect the presence of a prior FMD infection.

A rather recent discovery—and a further complicating factor in susceptibility studies—is not only that carrier cattle may cause changes in the virulence and antigenicity of FMD virus, but also that passage of the virus from immune cattle may lead to changes in virus subtypes. This condition explains, perhaps, the development of new subtypes in the field in areas where FMD is enzootic.

Cytological

ONE of the troublesome problems in studying virus-host relationship is that cells *in vivo* are influenced by products of other cells, whereas cells *in vitro* lack these natural defenses; hence experiments in host-cell susceptibility must make allowances for these differences. Choice of the appropriate tissue culture for *in vitro* studies, therefore, becomes extremely important, particularly because *in vitro* studies permit a much broader scope of research activity than do *in vivo* studies.

Early experimenters used plasma clot explant cultures and minced guinea pig embryo suspensions in *in vitro* FMD virus studies. In 1955 the Laboratory demonstrated that FMD virus produced a cytopathogenic effect in monolayer cultures of calf and swine kidney cells. By 1962, procedures had been perfected for the rapid and large-scale production of virus, using bovine kidney cells. In the meantime, research had been proceeding on the efficacy of using baby hamster kidney cells for the isolation, growth, and assay of FMD virus. This cell

line has since proved to be quite advantageous for virus culture of both FMD and African swine fever, particularly because it is adapted to large-scale production. Present output at the Laboratory is approximately 100 milligrams of pure FMD virus per week.

Tissue cultures appear to be the only test system in which mutants can be studied quantitatively. Thus, various means are employed to alter cell characteristics in order to determine the pathogenicity and growth characteristics of these viruses in different hosts.

Production of interferon—a substance that prevents spread of infection to other cells—is also studied in the tissue culture test system. Its production is an index of the degree of interaction in virus-cell systems.

Biochemical and Physical

NEARLY two decades of research at the Plum Island Animal Disease Laboratory has yielded a wealth of information about the biochemical and physical properties of the FMD virus. As a result of these studies, we may know more about this particular disease virus than we know about any other one. Much of this knowledge acquisition can undoubtedly be attributed to (1) the advent of electron microscopy, and (2) an awareness of the intracellular mode of action of viruses through the discovery of messenger RNA.

The virus particle is made up of a protein coat which protects a core of ribonucleic acid (RNA) molecule that needs to replicate for its own survival. The genetic power is in the core itself. When the messenger RNA takes over a normal cell, it, in effect, gives orders to the cell so that the normal cell cannot perform its normal functions. Instead, it must produce more virus particles. The infecting process is extremely rapid; within two hours after contact, with the host cell (or animal), growth of virus cells—and spread of the disease—begins.

Much knowledge has been gained as to the function of FMD virus-specific RNA polymerase which is synthesized early in the latent period before actual infection.

Present research is directed toward learning more about (1) the protein coat—its structure and sequence of the amino acids, (2) the molecular reactions involved in FMD virus ribonucleic acid replication, and (3) how the FMD virus controls host cell metabolism.

Immunological

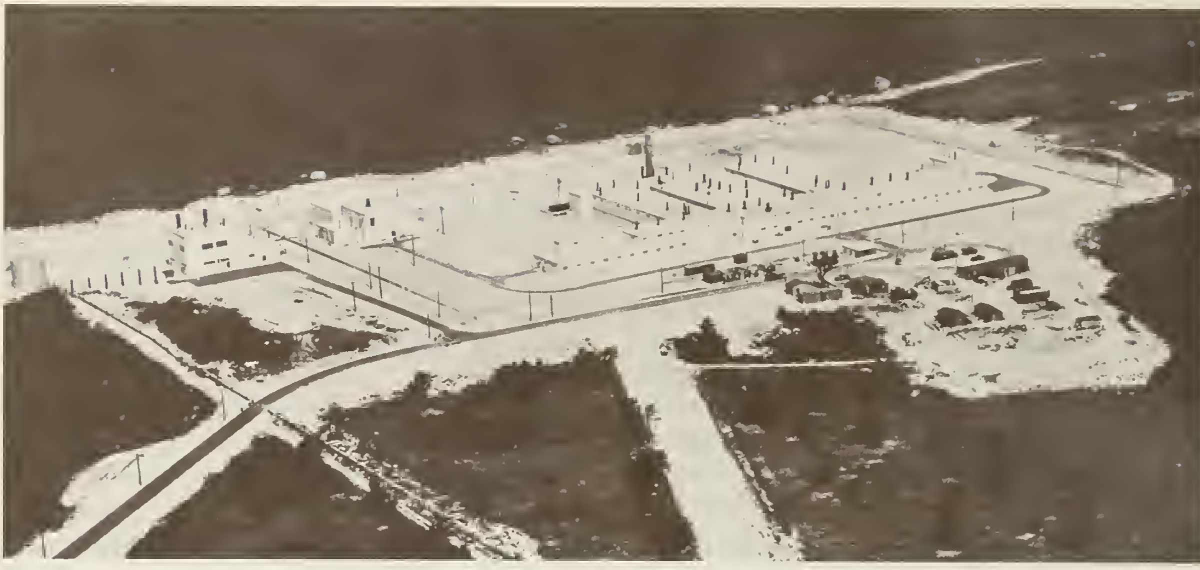
IMMUNOLOGICAL research at the Laboratory is aimed primarily at developing vaccines that will provide a reasonable degree of immunity to a disease. With some diseases, notable gains have been made; with others—for example, African swine fever—development of a successful vaccine remains an elusive problem. It seems reasonable to assume, however, that as our knowledge of virus properties and actions expands, the probability of success in developing new vaccines will also rise.

Although a vaccine for use against contagious bovine pleuorpneumonia has been available for many years, research continues on ways to improve it. The T–1 vaccine now being used in West Africa confers a practical immunity for about 1 year. Nearly 3 million doses were produced in 1970. Yet there is a need for finding ways to stabilize this vaccine, to evaluate the duration of the immunity it provides, and to learn more about methods of administration and the necessary frequency of use.

The first vaccine used against foot-and-mouth disease was developed by European scientists, Schmidt, Waldman, and Kobe in the late 1930's. An inactivated type obtained from tongue lesions of cattle, it was costly to produce and was later modified by the Holland scientists, H. S. Frenkel, in 1951 who propagated the virus *in vitro,* inactivated it with formalin, and then adsorbed the virus to aluminum hydroxide gel. This vaccine affords immunity for 3 to 6 months, following which, if the animal is to be fully protected, it must be revaccinated. Various forms of this vaccine are now in use throughout the world.

Live FMD vaccines prepared from virus attenuated by repeated passage through other animal tissue forms have been produced and used in experimental trials. There is some question, however, as to whether these live vaccines are safer or afford better immunity than the classical Schmidt-Waldman vaccine. Even the inactivated vaccines may contain infective virus at times, as a number of trials have shown.

Another factor that poses a serious problem in the use of FMD vaccine is the existence of various strains of the virus and innumerable subtypes



This main laboratory complex, situated on the north shore of Plum Island, was designed and built specifically for research study on highly communicable animal diseases.

of strains. To give the best control, a vaccine should be made from the same virus strain present in the field, or from one of the same subtypes.

Present research on FMD vaccines is focused primarily on improvement of the types now in use. Three essential features are being sought: safety, effectiveness, and relatively low cost. The vaccine must be so safe that vaccinated animals run no risk of getting the disease. It must be sufficiently effective that a single dose produces enduring immunity in all susceptible species of domestic animals. And because of the large quantities of vaccine needed, production methods must be as economical as possible. Most of the vaccines now in general use fail in one or more of these characteristics.

A number of specific questions need to be answered in attempting to produce a better vaccine. What virus strains will provide the optimum degree of immunization? What is the minimum effective dosage? What chemical should be used for inactivating the virus? What is the most suitable adjuvant? The inactivating process itself is an extremely delicate operation and was once described as comparable to that of tuning a fine Stradivarius violin. The whole virus must be inactivated, and at the same time the protein coat must not be degraded.

Within recent years, the Laboratory has been expending considerable effort on studies of the immunochemistry of FMD antigens. The chief objective is to determine the immunological, biological, chemical, and physical characteristics of antigens occurring in foot-and-mouth disease. These studies have yielded much useful data, and several experimental vaccines have been developed as a result of this research and some of these experimental vaccines will be field tested in several South American countries.

Cooperative work with the East African Veterinary Research Association in Kenya has been especially productive in studies on East Coast fever—a tick-transmitted protozoan disease of cattle. Spurred by the success of W. A. Malmquist in propagating hematozoa in the laboratory, the research group now handling this investigation feels that the development of a vaccine may be feasible. This research is particularly significant because of the implications for certain human diseases.

Other Areas

THE Plum Island Laboratory has pioneered in the use of electron microscopy and ultracentrifugation in studying the characteristics of viruses, their interactions with other cells, and associated anti-

gens. These studies are especially useful in detecting antigen-antibody complexes, in characterizing related enteroviruses, and virus identification and replication.

As in many other areas of science, investigations at the Laboratory frequently produce masses of data that, in the precomputer age, would have required considerably more time and manpower to analyze and interpret. Now, however, the installation of desk-top electronic calculators enables both scientists and technicians to process voluminous data speedily and with less expense. At present, 80 programs for virology studies have been written.

PRESENT STATUS AND FUTURE PROSPECTS

An evaluation of the impact of the research programs at the Plum Island Laboratory on the status of foreign animal diseases in the United States cannot, of course, be logically separated from the efforts of regulatory and control agencies. The two efforts complement each other and are fundamental components of any nation's plan to hold down the incidence of a given disease or to prevent it from entering the country.

The real thrust of a disease research program is the weaponry it provides in the form of added knowledge about causes and control. In that respect, therefore, the Plum Island programs have been productive ones, because we know much more about many exotic diseases than we did prior to 1954. And one might reasonably speculate that without this reservoir of knowledge, we may well have had more outbreaks of exotic diseases.

The activities of our research programs have necessarily reached out into many remote corners of the world—not only in cooperative investigations in actual areas where exotic diseases occur, but also to provide help in diagnostic services and to share knowledge in educational and training programs. For example, within a few weeks after report of the recent African swine fever outbreak in Cuba, a diagnostic training program was initiated at the Laboratory for veterinary scientists from Mexico and Central America.

There are valid reasons for such worldwide assistance and cooperation in the control of animal diseases. Wherever our efforts materially help in the control of a disease, the chances of that disease getting into our own country are lessened. Furthermore, wherever a country—particularly a developing one—enjoys the favored status of a vigorous and plentiful livestock industry, its economic position rises—to say nothing of the advantages of a quality protein supply for its people. The research and diagnostic programs of the Plum Island Laboratory are quite likely, therefore, to broaden their bases of operation at the international level.

For some diseases, man may have to continue for a while to recognize the simple one-world concept of a disease organism and meet it at its own primitive level and destroy both the virus and its host. But, hopefully, as our knowledge of these exotic disease organisms increases, ways will be found to further diminish their incidence through more effective use of immunization and improved methods of control.

WHEN FMD STRIKES

A Preparedness Plan for the United States

E. E. SAULMON

ALTHOUGH foot-and-mouth disease (FMD) has not gained entry into the United States since 1929, many changing factors are increasing the possibility of the disease getting in.

World trade is rapidly expanding. Each year we import more than 1 million live animals, nearly 2 billion pounds of meat, and about $200 million worth of animal products such as hides, wool, and casings. Unfortunately, some of the meats and meat products are smuggled illegally into the country.

International travel is also increasing. From 1962 to 1968, passengers entering the United States from foreign countries have increased from 160 to 218 million a year. There are many documented cases where man has spread FMD by carrying the virus on his clothing and footwear. For example, in previous U.S. outbreaks, almost one-fifth of the cases of herd infection was attributed to the spread of virus by man. We know of many recent cases where American cattlemen visited livestock premises in FMD-endemic countries and then returned to the United States where they came into contact with livestock a few hours later without cleaning and disinfecting their clothing and footwear. Although we got away with it these times, the chance is always there that this will be the means by which the disease is again introduced into the United States.

Travel time between countries and between continents is being drastically reduced. At the turn of the century, a trip from another continent to the western hemisphere required weeks of sea travel. If any animals had been exposed just prior to shipment, there was sufficient time for the disease to develop and they could then be destroyed. This time lag served as an important factor in reducing the risk of entrance of FMD. Today, a 6-hour plane trip offers little, if any, protection.

Natural geographic barriers are rapidly disappearing. The last remaining barrier between the FMD-endemic countries of South America and the United States is the Darien rain forest between Co-

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This article was adapted and updated from a paper presented by the author at the 72nd annual meeting of the U.S. Animal Health Association, Oct. 6-11, 1968, New Orleans, La.

lumbia and Panama. Civilization is slowly encroaching on the Darien jungle, and when the Pan American highway is completed, it will pass through this natural barrier and thus greatly increase the risk of entry of FMD to Panama, Central America, and North America.

The Alternatives

WE must face reality. FMD *can* get into the United States again as it did in 1902. Because of this possibility, we must plan what we are going to do when it happens.

If we did nothing, FMD would, of course, spread rapidly over the entire country. (In the Mexican outbreaks, for example, the disease spread up to 500 square miles a day.) It has been estimated that FMD increases the cost of producing a given quantity of meat and milk by about 25 percent in those countries where it is endemic. And since the United States is the world's largest producer of animal protein and milk, the cost of allowing FMD to become endemic here would be staggering—probably in excess of $5 billion a year.

One possible approach for controlling an epidemic here would be to use vaccination. Turkey, Israel, and Argentina—and most European countries—have government-subsidized vaccination programs that have greatly reduced losses. Such programs, however, are expensive and it is estimated that a national vaccination program for the 200 million head of livestock in the United States would cost about $1 billion a year. It should be realized, also, that the disease could not actually be eradicated in this manner; therefore, the cost would occur annually.

The most feasible economic approach for the United States is to eradicate the disease. The success of eradication depends upon the successful functioning of three important operational steps: early detection, rapid destruction of infected animals, and safe disposal of carcasses.

Eradication Costs

THE cost of eradicating FMD if it strikes the United States is difficult to predict and would vary greatly, depending on factors such as (a) the virulence of the virus, (b) location of outbreaks, (c) rapidity of reporting, and (d) whether diseased animals get into marketing channels.

The most recent examples of eradication costs are the 1946–54 Mexican outbreak, the 1952 Canadian outbreak, and the 1967–68 British outbreak. In the 1946–52 and 1953–54 Mexico outbreaks, over 1 million head of livestock were destroyed before the disease was eradicated. The United States cooperated with Mexico in this campaign at a cost to the United States of over $137 million.

The 1952 Canadian outbreak occurred during mid-winter near Regina in the province of Saskatchewan. Snowfall was so heavy that movement of man and animals was severely curtailed resulting in a very slow spread of the disease. Canadian officials estimated cost of eradication to be approximately $1 million. Because of climatic differences, it seems likely that the cost of eradicating a similar outbreak in the United States would have been much greater.

The 1967–68 outbreak in the United Kingdom resulted in the destruction of approximately 2 percent of their cattle, 1½ percent of their swine, and ½ of 1 percent of their sheep. If the United States suffers an outbreak of that magnitude, our eradication costs will be approximately $3 billion. Although many factors will influence costs of eradication, two of the most important are the time which elapses between the first occurrence of disease and start of an efficient eradication program and whether or not diseased animals enter marketing channels. Our expected range of foot-and-mouth disease eradication cost is from $1 million to $3 billion depending on the circumstances involved. But even if costs reach the upper limit, it will be cheaper to eradicate than to spend up to $1 billion a year to vaccinate.

If we intend to eradicate foot-and-mouth disease when it happens here, there will be a need for large numbers of veterinarians, livestock inspectors, and other personnel and a vast quantity of equipment and supplies. During the height of the recent British outbreak, over 10,000 persons (including approximately 900 veterinarians) were engaged in the eradication program. Large quantities of equipment and supplies for digging burial pits, burning carcasses, and cleaning and disinfecting must be immediately available for each farm found infected. An infected animal has been likened to a manufacturing plant in that it is continuously producing more virus; therefore, in order to prevent the further

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multiplication and spread of virus, infected animals should be slaughtered and their carcasses disposed of as rapidly as possible.

Eradication will require that every segment of the livestock industry—owners, markets, packing plants, dealers, and regulatory officials—cooperate in the detection of disease and the control of its spread. We must have the legal authority, manpower, and money to accomplish complete control of livestock movements.

The U.S. Plan

THE United States has a basic plan for conducting an eradication program; however, if the outbreak is large, we will be woefully short of personnel. Each State has an emergency animal disease eradication organization with personnel specifically assigned. Test exercises are conducted annually to assure capability to deal with any foreign animal disease outbreak. A national organization has been established with headquarters at Beltsville, Maryland. A special ready room has been developed and equipped with a communication system. Large maps of the United States and county maps for each State are part of the ready room equipment. Personnel have been assigned to each specific duty at the ready room, and test exercises are conducted to train new members of the organization and sharpen the skills of the older members.

A tri-agency agreement between the U.S. Department of Agriculture, the Department of Defense, and the General Services Administration has been signed, which provides that the military will furnish and deliver certain supplies, equipment, and services as required by the national interest. The General Services Administration has assembled and stored in seven different locations, supplies necessary to initiate eradication procedures. These supplies, which include disinfectants, rubber clothing, tools, spray pumps, and other essential equipment can be airlifted to any part of the United States in a few hours.

USDA has 65 veterinarians who have received special training in the diagnosis of foreign animal diseases and also a number of veterinarians who worked in the British and Mexican outbreaks. These men will form a sound nucleus around which we can build an eradication organization.

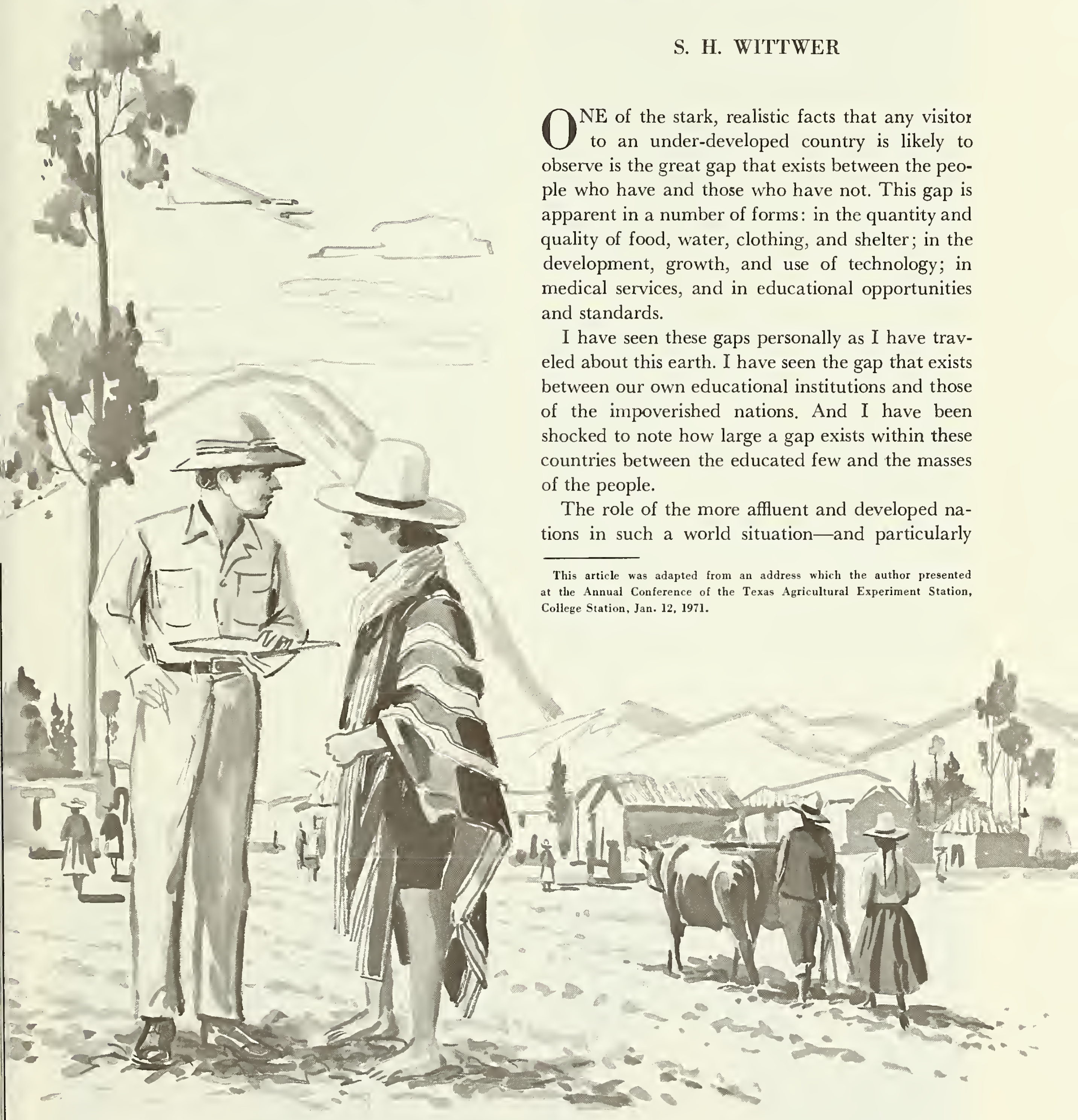
The experience gained by the 12 USDA veterinarians who visited England and assisted them in their eradication program has pointed out many weaknesses in our plans and in our preparedness. Except for the experience in Mexico and to a much lesser degree in Canada, we have not had an opportunity to apply FMD eradication principles for more than 40 years. One of the explanations of the great capability of England in combatting this disease is that they have had outbreaks over the years by which they could refine and improve their techniques. More important, it has kept them abreast of the drastic steps that are necessary to be successful and has kept those officials who have responsibility for such endeavors alert to the importance of recognizing the threat and being prepared to move rapidly and with decision.

Economic Impact

FOOT-and-mouth disease or many other exotic diseases of livestock pose a tremendous threat to the total economy of our country. With all of our preplanning and attempts at preparedness to overcome such a threat, we must recognize that we still have much to do. When foot-and-mouth disease gains entrance into this country, we can but assume the worst. If it should get into our marketing channels before recognition, we know it would become widespread. The impact on the livestock industry and the total economy of this country would be disastrous. Assuming even a proportion of the magnitude of the English outbreak of 1967–68, we can anticipate severe curtailment of the activities of the livestock industry—which would reduce or temporarily eliminate the income of thousands of people associated with the livestock industry, including transportation, marketing, slaughtering, and processing. All segments of the livestock industry will have responsibilities if FMD should strike here. Failure to recognize responsibility in reporting suspected conditions, or indecisive action even by 1 day, could inflict a serious blow to the U.S. preparedness plan.

Broadening the University Outlook Through INTERNATIONAL INVOLVEMENT

S. H. WITTWER



ONE of the stark, realistic facts that any visitor to an under-developed country is likely to observe is the great gap that exists between the people who have and those who have not. This gap is apparent in a number of forms: in the quantity and quality of food, water, clothing, and shelter; in the development, growth, and use of technology; in medical services, and in educational opportunities and standards.

I have seen these gaps personally as I have traveled about this earth. I have seen the gap that exists between our own educational institutions and those of the impoverished nations. And I have been shocked to note how large a gap exists within these countries between the educated few and the masses of the people.

The role of the more affluent and developed nations in such a world situation—and particularly

This article was adapted from an address which the author presented at the Annual Conference of the Texas Agricultural Experiment Station, College Station, Jan. 12, 1971.

that of the United States—is unmistakably clear: international involvement and commitment by putting to work some of our vast human and technological resources in an effort to close these gaps. I believe the State universities in our land-grant system are best equipped to assume this commitment. The scope of our involvement needs to be broadened far beyond that in which we are now engaged.

There is so much that the U.S. land-grant universities have to offer in the fulfillment of international programs. Our unprecedented progress in agricultural technology and achievements in food and fiber production make it reasonable to suggest that we apply our knowledge in these areas as an investment in the less fortunate two-thirds of the human species—an investment in the future of all mankind.

Why agriculture? Agricultural development is still the first priority in every under-developed country of the world. Before any nation can turn seriously to manufacturing or public works, it must first attain self-sufficiency in food, clothing, and shelter. Every other issue becomes grossly irrelevant in the face of this fact.

The urgency of the need for a broadened commitment of the land-grant universities in international programs was perhaps best expressed by Richard Nixon a year before his election as president: "America's basic self-interest in world development stems from the brutal fact that there can be no sanctuary for the rich in a world of the starving." [1] The truth of that statement assumes even greater significance when we consider that modern achievements in transportation and communication—rivaling even those in food production—make it impossible for anyone to live on an island.

About 6 years ago I had my first opportunity to see first-hand some of the agricultural problems in a less-developed country—in this case, Ethiopia. At that time 95 percent of its 22 million people were producing food, and nearly half of the remaining 5 percent were in the military. I was there under the auspices of the Rockefeller Foundation. This same Foundation was also supporting a predoctoral Fellow, Samu-Negus Haile Mariam, at Michigan State University; I was his major professor.

During my stay in Ethiopia, my itinerary included visits at the Haile Selassie I University in Addis Ababa and the Agricultural College at Alemaya, both of which were receiving technical help through a USAID contract with Oklahoma State University. I shall never forget the contrast in agricultural research facilities I observed at Alemaya and those at my own institution—Michigan State. Neither will I forget the need I saw for immediate efforts in problem-solving research. At Alemaya, sophisticated equipment was of no value, and if available could not be operated or repaired.

As a result of these observations, I quickly con-

[1] Address to the National Convocation on World Hunger, the National Industrial Conference Board, Sept. 12, 1967, N.Y.

A Vietnamese farmer shows a technician his Taiwan variety of yard-long beans which had insect problems. AID advisor Allen Hankins watches.—USAID photo

cluded that the kind of graduate training I was giving my Ethiopian student was ill-suited for his needs when he would return to his homeland. Upon my return to Michigan, I promptly made some adjustments in his training program, among which were special laboratory experience in soil testing and plant tissue analysis and some training in practical agriculture. I have often reflected on this experience, and I am convinced that we need to change many of our training programs in American universities so that they are better adapted to the needs and resources of the countries we are assisting.

The New Look for the 1970's

THERE are a number of approaches that universities can take to broaden their outlook in international involvement for institution building. Utilizing all of them could result in a "new look" for the 1970's. Of particular importance is the plan which George Axinn [2] and I would label the long-term/short term arrangement. Outstanding, highly productive scientists would be selected for foreign assignments. Each would have a research interest in, and would identify a counterpart for, a particular problem or area of work in the developing country. He would develop a long-range work program with his foreign colleague. The initial visit of the American scientist might be for 3 months, followed by return visits at yearly intervals for a period of 8 to 12 years. Return visits might range from 2 to 6 weeks and more frequently than once a year.

Between engagements there would be regular correspondence, including an exchange of data and biological material. Reports and articles for professional journals would be co-authored. There would be a sharing in the guidance of graduate students. A graduate student exchange program would be developed with the opportunity to channel or direct an exchange of field and laboratory experience. The U.S. "long-term/short-termers" would also participate, while on the foreign campus essentially as visiting professors, in discussions of curricula, training programs, giving lectures, and presenting seminars. The co-partner of the institution of the developing country would do likewise in our universities. Foreign laboratories could be very effective in the training of our graduate students in certain problem areas.

As a research scientist, I can affirm that the long-term/short-term arrangement would be attractive to our very best people. There would be the appeal of travel and the opportunity to visit en route other research institutes and establish new and reoccurring professional contacts. Thus, they could become vigorous participants in a worldwide network of communication related to a particular crop, commodity, or discipline.

The long-term/short-term arrangement has the potential to build confidence in the staff of emerging agricultural universities in developing countries. This plan features the "visiting professor" concept rather than that of advisor. Distinguished scholars, many of whom are our former students, could be encouraged to come to our campuses from abroad—both from Asia and Europe—thereby establishing a better pattern of relationship with our foreign alumni.

A greater focus on adaptive research is needed in some of our international programs to make up for the unsuitability of applying our own high-level technology to the needs of developing nations. Most of these countries have climates, soils, cropping systems, and harvesting and processing systems that are quite different from those in the United States and Europe. Where these differences occur, adaptive research leading to new technology is required.

One of the handicaps that any nation with an international comittment ultimately faces is the scarcity of trained and educated manpower in many of the developing countries. Wherever illiteracy exists, the aiding institution can find itself facing day-today discouragement in the fulfillment of its role.

One way to overcome such a handicap would be to establish research and education programs on U.S. campuses—particularly those in the South and Southwest—geared specifically to certain needs of the developing countries. Texas, for example, with all its expertise in crops ranging from the temperate zone to the tropics, might offer a course in world food crops.

Other possibilities for U.S.-based adaptive research and education programs include (a) those that would cover animal agriculture (with all its exotic breeds) on a global basis, and (b) agricultural engineering programs adaptable to the needs

[2] Executive Director, Midwest Consortium for International Activities, Inc., Michigan State University, East Lansing.

for knowledge in water management, low-cost housing, and semi-mechanization in the production and harvesting of crops in developing countries with large labor supplies.

There is a strong case for greater research emphasis on food legumes for developing nations, particularly soybeans, cowpeas, chickpeas, pigeon peas, field beans, and peanuts. These crops are widely adapted to the tropics and the arid areas in Latin America and Africa. Many are drought-resistant and productive in low moisture areas where the annual production of cereals is not feasible. The "grain markets" in many of these countries consist primarily of the seeds of legumes.

Food legumes are high in protein and already serve as a major protein source for the people. The naturally occurring, nitrogen-fixing bacteria—the rhizobia—fix atmospheric nitrogen in the root nodules, thus eliminating the cost and necessity of applying nitrogen fertilizer for crop production. New and sensitive techniques are available to determine the magnitude of biological nitrogen fixation (nitrogenase activity) under agronomic conditions, and now there is the opportunity to genetically and culturally optimize the process.

Legumes also provide a diversity and an alternative in plant protein sources as a protection against major devastating pathogens which may afflict cereal crops. Many are still only a step or two above the primitive forms. The potential for varietal development is greater than for any other major group of crops.

The benefits that can accrue from adaptive research are particularly evident in the case of the Far East, where food production increased 4 percent last year for the third successive year. In speaking of this achievement, A. H. Boerma, Director General of the Food and Agriculture Organization of the United Nations, says the gains show what can happen when governments are firmly committed to agricultural development.[3]

India, whose teeming population has often faced severe hunger, had a solid 5 percent increase in food production during the past year. The less-developed countries as a group had increased total production by an average annual rate of 4.8 percent between 1950 and 1967.

The FAO report states: "It seems reasonable to hope that the high-yielding varieties of cereals will make it possible to overcome the worst calorie deficiencies in many of the developing countries during the course of the 1970's. They should also help to reduce the scourge of protein deficiency that particularly afflicts so many children, both because cereals are man's main source of protein, and because higher yields of these dominant crops can release land for other purposes, including feed production."

Despite these gains, much more adaptive research needs to be done. For example, although substantial progress has been achieved in developing a high-protein corn in the United States, researchers in the less-developed countries are having difficulty in breeding cultivars more ideally suited to their particular soil and climatic conditions.

It seems to me that a number of land-grant universities in the United States are richly endowed with the facilities, the climatic range, and the expertise for greater involvement in adaptive research in international programs.

Success of Foundations

THE success of the international programs of foundations—notably Ford, Rockefeller, and Kellogg—might be considered a guide in broadening our outlook through international involvement. It is well to note that these foundations concentrated on (a) the most important crops—rice, wheat, corn, grain sorghum, and (b) the most impoverished nations—India, Mexico, Pakistan, Philippines. They assembled interdisciplinary teams of skilled, dedicated scientists from many nations. They were truly international.

The results of foundation programs have made the headlines. Yet we need to remember that the leaders and many of the working scientists at the international research institutes were graduates—the products, so to speak—of land-grant universities. They had their training in the systems we represent. The field, along with the penetrating observant eye of the investigator, has been the laboratory. No fancy facilities, nor sophisticated equipment awaited these scientists when they initiated their studies.

Even today, after 26 years, Norman E. Borlaug, recent recipient of the Nobel Peace Prize and his associates at International Maize and Wheat Im-

[3] See: *The State of Food and Agriculture, 1970*, FAO, Rome.

FAO agricultural specialist Donald Wadsworth lectures to a group of students at the Mechanized Agriculture Training Center at Pasar Minggu near Djakarta, Indonesia.—FAO photo

provement Center (CIMMYT) work in crowed offices in a rented building where the floors squeak and there is no air-conditioning. Plans and construction are now underway for a modern facility at Chapingo. The important message here is that the Peace Prize was won on the basis of work conducted in the absence of what we usually consider the necessities for conducting good agricultural research.

Multilateral Funding and Consortia

TWO relatively new developments in international programs should help to broaden the outlook of American universities: multilateral funding and university consortia.

Future directions of the United States Agency for International Development (USAID) indicate it will be receptive to supporting established successful institutes such as CIMMYT, International Rice Research Institute, Center for Investigations of Tropical Agriculture and the developing Internatonal Institute for Tropical Agriculture (IITA) in Nigeria.[4] It will render assistance for these research centers and institutes, along with the foundations, the World Bank, the Southeast Asian Bank, and private industries. As with funding, project sponsorship should become multilateral. The United Nations Development Program and other agencies could be involved. We should attempt direct contracting tied with developmental organizations within the foreign country. These organizations may not have existed 10 or 20 years ago, but they do now.

Other concerns of AID are that the lives of the people in developing countries are improved and that the resulting economy reflects an increase in the gross national product. Problem-centered programs will be developed and effected under the existent political power structures. These will relate to the lack of availability of low-cost, highly nutritious food, the difficulty of reaching the preschool child, and the inability to move food from production areas to consuming centers. As we create new programs to maximize agricultural production and increase the gross national product, we must become increasingly aware of the quality of living and environmental issues. Family planning ought to be a part of such efforts.

The second new dimension is the university consortium for international programs. The focus for the 1970's appears to be on linkages between groups of U.S. universities and their counterpart institutions in other parts of the world. Ultimately, this could result in a functioning worldwide network for higher education and research.

There is already a maze of university consortia in the United States. All kinds of cooperative inter-university agreements are emerging. The Midwest Universities Consortium for International Activities, Inc. (MUCIA) was organized in 1964 with

[4] From a talk by Samuel Butterfield, Deputy Asst. Administrator, Technical Assistance Bureau, presented at the Plant Breeding and Food Fortification Conference, Annapolis, Md., Dec. 8–10, 1970.

Indiana, Illinois, Wisconsin, Minnesota, and Michigan State as participating members. CUSURDI, known as the Council of United States Universities for Rural Development in India, is comprised of Illinois, Ohio, Pennsylvania, Missouri, Tennessee, and Kansas. The Consortium for the Study of Nigerian Rural Development is known as CSNRD and includes Colorado, Kansas State, Michigan State, Wisconsin, USDA, USAID, and USDI, plus the Triangle Research Institute of North Carolina with Duke University, North Carolina State, and the University of North Carolina as participants. MASUA is the Mid-American State Universities Association with Iowa State, Oklahoma, Kansas State, and Nebraska. An arid lands consortium in the Western states consists of Wyoming, Utah, New Mexico, and others. SUNY represents the State Universities of New York. There is a southern consortium of Georgian universities, and we could name others.

As a result of negotiations now in progress, a consortium of Texas A. & M. University, Pennsylvania State University, and Michigan State University is a very lively possibility.[5] All three are currently involved in providing technical assistance through AID to the regional graduate school at Castelar in Argentina.

The university consortia have many advantages. They are actively involved in overseas technical assistance and institution-building programs. Contracts are negotiated with the Foundations, USAID, USDA, and other public and private agencies. Top-level, high-quality experts in almost any academic field can be mobilized as consultants. Teams for critical analysis and evaluation of developmental programs can be assembled, including those having social science dimensions. Exploratory studies of the feasibility of major overseas projects can be conducted and supported. Another advantage is that greater sophistication and skill are needed in development tasks. Also, we now have competition from abroad. Denmark, Sweden, the Soviet Union, Germany, and United Nations are heavily involved in programs for emerging nations. Just as inter-institutional and inter-disciplinary attacks are now needed to solve our major domestic problems, so do foreign development programs thrive on such an approach.

A salary guarantee fund has been provided in at least one consortium—the Midwest Universities Consortium for International Activities (MUCIA), for which $1 million of an original Ford Foundation grant was set aside. This provision enables departments in universities to "over-staff" so that senior professionals are available for overseas assignments. Ideally, the plan enables a department head to carry enough full-time tenured personnel so that the equivalent of one or more can be involved continuously in overseas service or research.

Conclusions

AMERICAN land-grant universities can rightfully take pride in the progress achieved so far in their involvement with international programs. Many heretofore deficit countries—particularly in Asia and some sections of the Middle East—have achieved self-sufficiency in the production of food grains, or will shortly do so.

Other nations, however, have not fared so well—namely in Latin America and Africa. Here, food production increases have not kept pace with population, although admittedly a high birth rate and lack of adequate family planning contribute to the problem. What we need now is a so-called "green revolution" in Latin America and Africa, but it will have to be with the food legumes and root crops (cassava, sweet potato) as well as the cereal grains.

Viewing our international program involvement on a global basis, I believe we have reached the point where we ought to reappraise all our priorities—as to nations or continents most needful of cooperative programs, the food crops in most critical supply, both the degree and kind of assistance, and the manner in which we will deliver that assistance. How well we do in the decade ahead will ultimately be reflected in how successfully an individual nation maintains the momentum of growth and development from assistance programs it receives. If we are to achieve any measure of success in narrowing the gap between those who have and those who have not, it can come through deeper commitments from our land-grant universities as they seek to broaden their own outlook on international problems.

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[5] Since this article was written, the above alliance has been completed and is now known as the University Consortium for Inter-American Institutional Development.

SCIENCE DECISION MODELS

BOYSIE E. DAY

FUNDAMENTALLY, science decisions are not different from other decisions. To perceive why this is true, let us look at the situation from our own viewpoint—that of the management of science.

One view is that the first rule of science administration is to pick good scientists. The most important attribute of a good research administrator is the ability to recognize talent—in other words, the ability to hire bright people, productive people, innovative people. From this viewpoint the conclusion is that if you have such ability—and money—you can't lose. You can be a real stumblebum in all other aspects of running your shop if you have really sharp people and the money to support them. In fact, it might even be helpful to encourage your people to believe that you are a stumblebum. If they are really sharp, it makes them feel good.

The Four Ingredients

LET me expand this bit of reasoning, then, to consider an administration model based upon academic science as we know it. The model has four ingredients:

1. A staff of highly trained and truly creative people.

2. Excellent facilities to support them—libraries, laboratories, housekeeping systems, and adequate help to assist the scientists with their studies.

3. A system of rewards and withholding of rewards so as to recognize and stimulate accomplishment. This system must be based primarily on peer judgment—that is, judgment by entomologists as

This article was adapted from a paper presented by the author at the CSRS Conference on Science Service, Washington, D.C., June 29, 1971.

to what constitutes good entomology, or the opinions of engineers as to what constitutes good engineering.

Such judgments are purely value judgments, and yet they are astonishingly reproduceable in evaluating the quality of scientific research. You can appoint two different committees to evaluate a piece of scientific research and usually their opinions are in close agreement.

4. The fourth ingredient is that all other administrative functions should be low-keyed and sufficiently inconspicuous so that the working scientist can almost pretend they don't exist.

This, then, is the traditional model for a Cal Tech, an MIT, a Harvard, or other distinguished research institutions, in which the administrator not only doesn't try to direct what the scientists do, but often doesn't even know what they're doing. In fact, it would be improper for him to even inquire!

This model describes a highly productive system of research administration, even though it appears to lack some of the ingredients of a proper management system. It appears to have no master plan with its feedback loops to see that goals are met and that people work together instead of at cross-purposes to one another. How are priorities established and enforced? These and other seemingly unanswered questions and departures from rational procedure lead critics to look upon the system as no system at all. On the contrary, this view is an illusion. All of the components of good administration are present and intensely functional. The difference is that functions are often delegated in strange ways—to the learned societies for example. These powerful groups coordinate effort, focus motivation, dispense rewards, and apply sanctions in ways that supplement the exercise of these functions by research directors.

To my way of thinking, however, this fine system has certain faults, depending upon what one wants to get out of the research system. First of all, the system is highly responsive to, and highly focused on, disciplinary interests; but it is unresponsive and even detrimental to interdisciplinary research. The scientist gets his kicks and his licks according to how he does in his discipline. For example, you don't often find social scientists listening in on entomology seminars and vice versa. In fact, one of our own department people was explaining to me recently what he thought was a fine interdisciplinary research project: They had a bacteriologist and a virologist both working on the same problem!

You and I may think in terms of getting the physicists, the biologists, and the sociologists together. But don't try to do it. I have searched at length for a really fine example of interdisciplinary research, under the model that I speak of, and I can't find it. If any of you can find a really good example I'd like to know about it, because it does not happen in the academic atmosphere—or it happens seldom, at least.

These, then, are the attributes of this system. I can summarize this model by saying that the *trip* is the important thing—not the *destination*. We evaluate a person on the basis of whether he made a good "high-school try," even though he didn't get anything out of it in particular. The astonishing thing in this model is that, although the trip is the important thing and not the destination, very often he who sets out on it gets to a better destination than he who first carefully maps out the trip with a predetermined destination in mind.

The Industrial Model

LET us consider the opposite pole from the preceding model—the prescribed model for industrial research. Here, I recognize a number of components.

The first is project acquisition. You inventory and survey the need for research; you identify researchable problems.

Second, you evaluate possible projects on the basis of the value of solving the problem.

Third, you estimate the cost of the effort to solve the problem.

The fourth component in the evaluation is to estimate the probability of getting a workable solution.

On the basis of these factors we can estimate a net value for each project under consideration. Let us suppose we have a problem whose solution would save or earn $100 million, and that, if we were to do things the best way we know how, the attempt to solve it would cost $1 million. If the probability of success were 10 percent we can estimate a net actuarial value for the project of ten-fold the investment. We pick projects with high net value or high cost-benefit ratios.

The next step is to chop the project into its disciplinary components and then put these together into an efficient and practical management plan.

In this sense, the administrator becomes the interdisciplinarian. And indeed, I think this is true in industry and elsewhere. The only real interdisciplinarian is the administrator. In fact, going too far administratively toward forcing interdisciplinary cooperation is, in my estimation, counter-productive. Once these primary decisions are made, we can go ahead with the work while trying to maintain enough feedback to permit changes of direction. There should be constant review and supervision, and above all a mechanism for killing the project, if we see that it isn't going to work out. Killing a project, as you all know, is the lowest form of scientific murder—and the most difficult!

The model for industrial research is based on strong centralized management, with written projects, appropriate reviews, and a strong organizational structure. It fosters interdisciplinary research by encouraging subordination of the scientist's individual interests to the interests and goals of the team. There must be a mechanism built into it that rewards the man who places his disciplinary views secondary to the common goals. Judgments by project administrators must largely replace peer judgments in evaluating personnel.

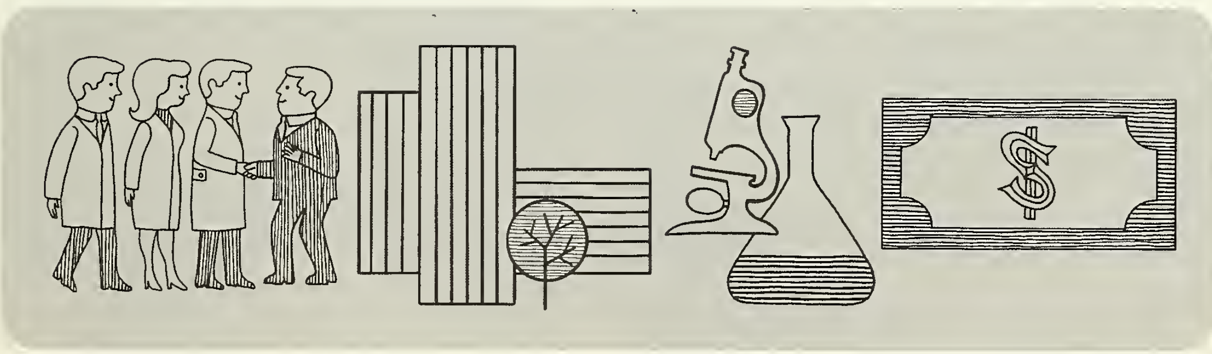
Variants in Our Own System

I have presented two extreme models of decisionmaking in science. I don't think that either of them ever functions in pure form. In the clutch, our decisionmaking rarely fits any clear model and we should devote some thought to this.

I think that a common basis for decisionmaking in publicly supported science is: Will a proposal sell to the legislature or Congress or some other agency? This is a logical and highly practical basis for deciding that a project has merit. On the other hand, a lot of our decisions are purely intuitive and subjective, and do not employ any consistent procedure. They are many decisions that must be made for which rational analysis provides little help.

Research administrators should first of all recognize that the truly creative and innovative work of the world is done by a trifling fraction of the population. Ten thousand ordinary fiddlers, put together in an appropriately stimulating environment, could not come up with the works of one Beethoven. However many projects we were to write and however skillfully administered, all we would get, I suspect, is discord.

Not only in highly creative work but in routine activities do we see great differences in productivity. Someone has said that about 90 percent of the useful work in the world is done by 10 percent of the population. Records show that 90 percent of all the used cars are sold by 10 percent of the salesmen. I'm not sure that's a great benefit to society, but somehow that fact has meaning for me. Records also show that 10 percent of the fighter pilots shot down about 90 percent of the enemy aircraft in World War II. I could cite further examples outside the world of science.



In the world of agriculture, about 90 percent of the agricultural produce—in my State, at least—comes from about 10 percent of the farms. And in the science publishing field, about 90 percent of the scientific publications—those that really qualify as quality scientific publications—are written by about 10 percent of our scientists. This proves that about 90 percent of us are freeloaders.

We as administrators see this all of the time and are tempted to think that we should get rid of the 90 percent and keep the productive 10 percent. I don't believe that it can be done. I say that we must have the 90 percent there because they are necessary. The productive 10 percent has to have the others around just for kicks if nothing else.

Most of the world's work, including research, is plodding routine. This constitutes the foundation that our fully productive people work on. We should recognize that although these 90 percent do not make great discoveries, they are the custodians of knowledge and keep a lot of dull knowledge alive. This is important, for knowledge exists only in the minds of men—not just in books. (If it's only in books, it constitutes a record but ceases to be knowledge.) Thus, the 10 percent stand on the shoulders of the 90 percent; without them they would not stand so tall. Yet scientists all seem to cost about the same, even though a small part of them do most of the identifiable work. Cost centers and production centers are not necessarily the same.

Basis for Decision-Making

KNOWLEDGE theory tells us that there are only two kinds of human thought—those ideas which can be verified or supported by empirical observations, and those matters that are purely value judgments which, by their very nature, can never under any circumstances be reduced to empirical measurement. Most of our day-to-day decisions are of the latter type—value judgments. These must be dealt with on an intuitive basis. I recently read an essay which said that the principal reason for this condition is that, in making almost any decision, we have at best only a small fraction of the information necessary to make the best decision. Our information is so scant that many of our most important decisions are, in effect, random choices. The main reason for this is that most of the factors involved in decisionmaking are actually random factors unknown to us because they lie in the future—and decisions must be made in the present. Such factors, therefore, are not only unknown to us now but are, in the nature of things, unknowable.

It is not my wish to end on so cynical a note. We badly need to improve our management of scientific research. We live now in a period of questioning and doubt of all of our institutions including organized science. Science has not given enough attention to rationalizing its administrative and decisionmaking structures. We must pay more attention to this.

Worldwide Outlook on Wood Housing

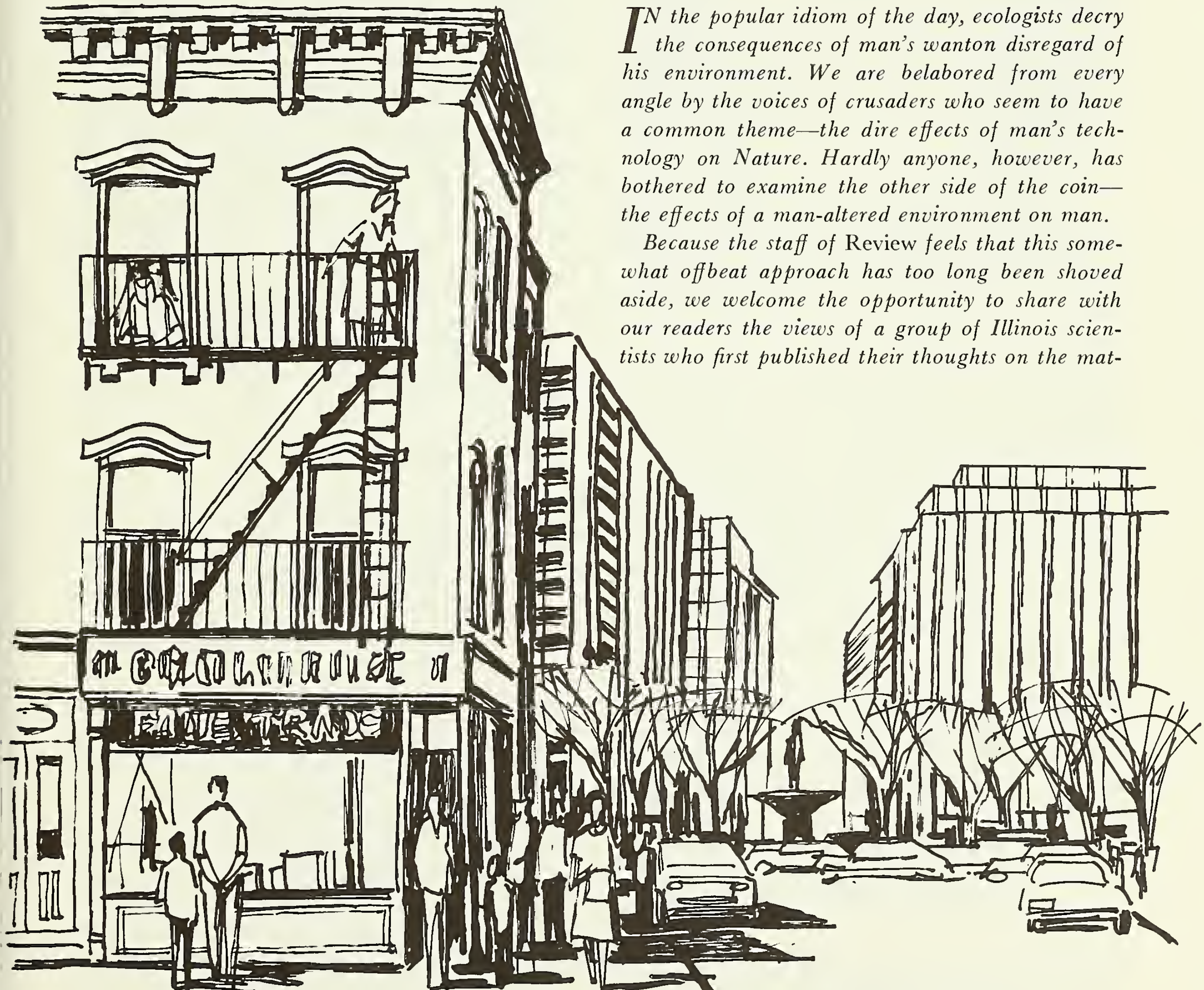
THE earth's forests are abundant enough to supply wood products for substantially more urgently needed housing than is now being built, and should be more extensively used because trees are renewable and wood building materials can be produced with less energy and less attendant pollution than alternative materials made of metals and petroleum. These were among major conclusions reached by the worldwide Consultation on the Use of Wood in Housing held last July at Vancouver, B.C.

The Consultation recommended greater use of wood for housing in all parts of the world where supplies are adequate; for the provision of technology on wood and its use in housing to developing nations; and for the establishment of planning, financial, and other agencies where needed to stimulate production of wood products and housing. A central international clearing house for technical information, with particular reference to design aids for timber engineering and building practice, was also recommended. Only about 0.5 percent of the world's growing stock of timber is now being used annually.

H. O. Fleischer
USDA Forest Service

Effects of a Changing Environment on HUMAN HAPPINESS AND WELFARE

ESTHER L. BROWN AND WILLIAM R. NELSON



IN the popular idiom of the day, ecologists decry the consequences of man's wanton disregard of his environment. We are belabored from every angle by the voices of crusaders who seem to have a common theme—the dire effects of man's technology on Nature. Hardly anyone, however, has bothered to examine the other side of the coin—the effects of a man-altered environment on man.

Because the staff of Review *feels that this somewhat offbeat approach has too long been shoved aside, we welcome the opportunity to share with our readers the views of a group of Illinois scientists who first published their thoughts on the mat-*

ter in Illinois Research, *official journal of the Illinois Agricultural Experiment Station.*

Evidence of the importance of their theme is best illustrated by the fact that their original article directly influenced the thinking of a Washington committee in drafting the official position paper of the United States in preparation for the United Nations Conference on Human Environment set for Stockholm, Sweden, in 1972. Thus, their reasoning may very well have significant effects on whatever goals and actions evolve from the conference.

THE United States is so new-oriented and technological developments come so rapidly that little if any thought is given ahead of time to their effect *on man.*

Changes, sometimes drastic ones, are made in the environment without considering how man may react to long-time exposure to change; how technological changes may affect man's production and consumption of resources in the environment; or how these changes may disrupt the entire ecology of a region. Consideration of man's place within the total environment means concern for the survival of productive human beings within an environment that will provide a desirable quality of life over a certain span of years.

It is a known fact that man responds both psychologically and physiologically to his environment, but the intensity of his response is unknown. Nor do we know to what extent man is threatening his own survival by technological interference which may impede or disrupt nature's self-regulating mechanisms.

The need for systematically relating man-made environments to natural ecological systems is manifest. Interrelated with this need—and equally important—is the need to understand the effects of both manmade and natural environments upon human society and behavior.

Some of the obvious problems are the man-made ugliness of the environment, the destruction of natural beauty, lack of privacy, and inadequately arranged spaces inside and outside the home and other structures. These conditions constantly require man to adapt to environmental change and raise questions about human interaction with the environment. For example, how does the changing environment affect the unique values of individual and family life? And how has it affected the individual's ability to respond to stimuli (visual, aural, olfactory, tactile)?

One other question about the changing environment concerns its effect on human potentiality. Exploring human potential could become the meeting ground for a wide range of disciplines, offering a dynamic synthesis for seemingly divergent areas of research.

Research findings that indicate the point at which humans no longer respond overtly to unsightly and unhealthy aspects of the environment can provide the basis for new and innovative programs in resident teaching and Cooperative Extension. Such findings will also contribute to programs for improving the total environment.

Since work on these problems is so limited and in some cases new, it is difficult to give a perspective of research knowledge and needs. Instead, an outline of proposed research is presented in the following paragraphs.

Environment and the Family

ASSUMING the family to be the primary unit of society, we must recognize that it acts, reacts, and interacts within the larger social-physical environment. This interaction yields implications for individual as well as corporate functioning.

In what instances does the family initiate action? What environmental factors inspire and facilitate such initiated action? Which are impediments? When is the family acted upon? Does the family adequately serve the functions attributed to it? Is today's family maximizing both individual attainment *and* community development?

Finding answers to questions such as these does not fall strictly within any one framework of study. Rather, it will be necessary to tackle the problem through a number of separate, but related, studies. Following are six proposed lines of investigation.

1. Study human response to and interaction with the physical, psycho-social, and interpersonal environment.

This article was adapted from a paper published in *Illinois Research*, Vol. 12, No. 4, 1970, University of Illinois, Urbana. Assisting the senior authors in the study that led to publication of the findings were Harold H. Alexander, Associate Professor of Housing and Home Furnishings; Margaret R. Goodyear, Associate Professor of Home Economics; and Michael J. Sporakowski, Assistant Professor of Family Relationships.

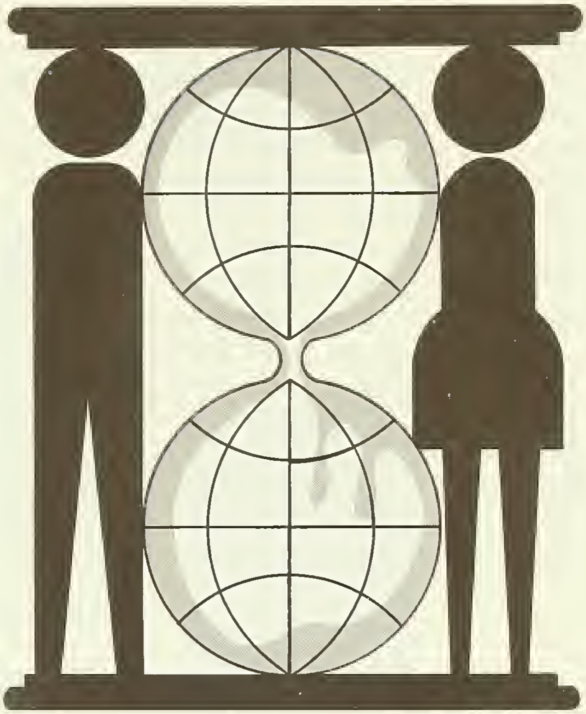
2. Study especially the family as a unit of response and interaction.

3. Study the criteria and methods used by the individual, the family, and other groups in making decisions that affect the near environment.

4. Evaluate and assess the effectiveness of the use of natural landscape elements to fulfill the human requirements for identity and a sense of place in the face of urban pressures, population growth, and technological changes.

5. Identify people's beliefs, values, and attitudes concerning the natural and artificial landscape as it relates to the home, neighborhood, and city, so that a framework of education and public service can be established to develop positive attitudes and behavior toward the land and landscape.

6. Develop criteria for combining plants, space, and man-made materials to provide meaningful, productive, and satisfying physical environments for human use. This would apply both to the home and to public areas.



Artificial Environments and Man

MAN, as the inhabitant of artificial environments created by human efforts, is either the victim or the beneficiary of these efforts. We are now in the midst of reshaping the environment on an unprecedented scale, but without a bridge across the chasm that divides behavioral sciences from natural sciences and the design professions. We need a behavioral basis for the designed use of natural elements (earth and plants) in order to develop artificial environments that provide for the social and personal well-being of man and for the preservation of recognized values of the earth and its natural resources.

The following list of proposals is meant to be illustrative, rather than exhaustive:

1. Determine how the natural landscape (those elements of the landscape important to people but rarely utilized) can be integrated with the artificial landscape (frequently utilized elements).

2. Permit more realistic planning by the design disciplines on the basis of information about human attitudes, awareness, and response to natural elements.

3. Provide resource material for a definitive public service program aimed at educating both youths and adults so that they will understand and be aware of their environment, recognize good design, and realize how it can be applied to rural and urban developments.

4. Establish a basis for expanded teaching programs in nonagricultural uses of natural resources and in urban horticulture.

The methods of the "hard" sciences, which rely heavily on laboratory and field experiments, would not be applicable to this project. Rather, it would be necessary to employ techniques of the behavioral sciences. Specifically, the project calls for systematic observation by an investigator with a feeling for the nature of the setting and the people. He must be extremely sensitive to the structure of the environment, the processes that are taking place, and the general characteristics of the people using the space.

Selection and Acceptance of Environmental Components

PEOPLE use varied criteria when selecting objects for their environment—furniture, accessories, paintings, the houses themselves. Ideally, one would believe that function and design, along with cost,

would be the dominant factors that people consider, but this does not seem to be the case. An insight into the reasons why one article of a particular design, make, or color will be selected instead of another of equal cost should be of great value in teaching housing, interior design, and environmental studies in general.

Insight is also needed into what makes people either accept or turn off what they consider the negative aspects of their environment.

The fact that the human being is capable of turning off that which bothers him, thus making life a little more bearable, has compounded the ills, both visual and physical, of our environment. The admirable qualities of our neighborhoods and rural areas are diminished by spreading "urban blight," and we human beings are aware for a while of what has gone, but soon apparently forget the loss. The process is repeated *ad infinitum*.

Eventually our environment become unbearable, and we must move or succumb. At what point did this happen? When did we turn off too much? Is a situation that we find unbearable still tolerable for others—others in another age group, another ethnic group, with a different level of education?

The attitude changes which occur as people become accustomed to a negative environment are indications of accepting or turning off that which is undesirable.

Investigations of these two points—people's criteria for selecting environmental components and the point at which the undesirable aspects of one's surroundings are accepted or ignored—are basic to the whole effort of improving environmental quality.

Sun, Wind and Water: Power for the Poor

FINDING solutions to the problems of millions of people whose everyday life is little affected by modern technology is the basic undertaking of the Brace Research Institute of McGill University, Quebec, Canada.

These people lie outside the mainstream of development. The objective is to provide them with a stepping stone for that day when, either through their own efforts or through developments within their own country, modern conventional technology is introduced.

The general strategy has been to study the social and technical needs of people living in arid areas and then survey science and technology to select suitable methods for satisfying these needs.

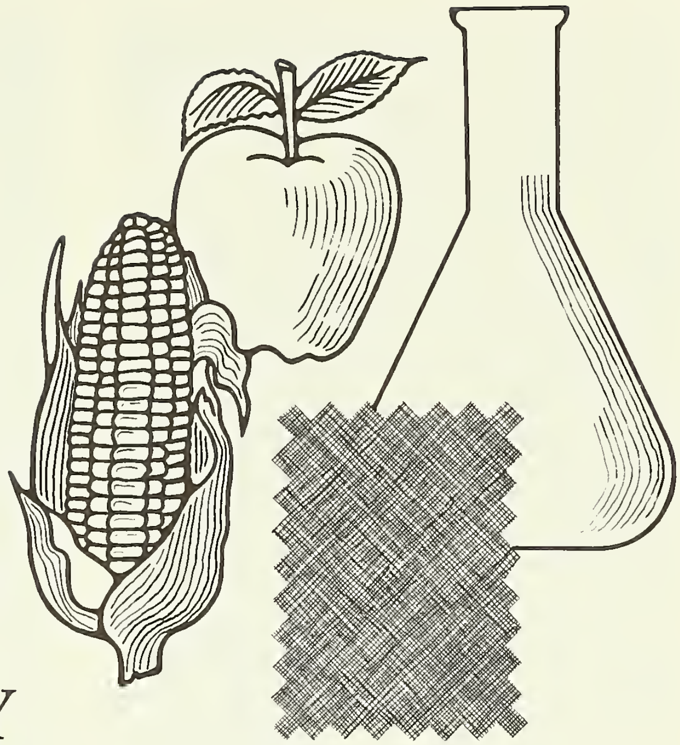
The Institute makes use of what is by and large locally available, and adapts technology so that the individual villager himself feels part of the overall achievement. That facet of the human equation so often neglected—the dignity of man—is taken into account.

Ten years of research by Brace Institute has produced the following results:

- the development of an accurate, low-cost instrument for measuring daily solar radiation.
- the extension of theory required for the design and analysis of solar collection.
- the development of a number of low-cost, family-sized, solar energy-powered devices for drying crops, cooking and for providing hot water for household uses.
- the development of several large agricultural crop dryers utilizing solar energy.
- the development of a low-cost, small-scale, wind-powered water pumping unit.
- the development of a 32 ft. diameter windmill suitable for water pumping and other applications.
- the development of numerous solar distillation units and the installation of several large scale units in the Caribbean. One of the Institute's more successful projects has been the installation of a solar distillation plant in a small community in Haiti. The inhabitants have been able to run and operate the plant for the last two years and the fresh water has had a marked effect on their economic and health conditions.
- the combination of solar stills with greenhouses for use in arid areas, so as to conserve fresh water.
- the development of a 10 HP, low-cost steam turbine to be used in conjunction with solar steam power.

T.A. Lawand
Brace Research Institute
From: *AIC Review*, 26:4, 1971.

FOOD, FIBER, and the ECONOMICS of ENTOMOLOGY



ALBERT A. LaPLANTE, Jr.

I am an economic entomologist. I deal with practical, money-oriented problems as a professional worker involving the interaction of insects and man. My career began at much the same moment as a more famous, or now infamous, entity known as dichloro diphenyl trichloroethane, nicknamed, DDT.

It is difficult to imagine, now, the excitement generated in our dedicated group by the impact of this easily constructed and manufactured chemical upon our plodding world of research. Previous to DDT we had classified our insect control chemicals as stomach poisons, those which killed insects by ingestion; and contact poisons, those which killed insects upon contact. DDT provided a double whammy by combining these actions in one marvelous, lethal package. We applied this miraculous chemical to our crops, slaughtered insects by the billions, and increased yields by astonishing amounts.

The reaction of the public was electric. We were heroes and assumed the omnipotence of gods. Bear in mind that this was in the year 1944. Victory gardens had sprouted like weeds all over this land. The inexorable tide of organic chemicals spawned by DDT ushered in the organic age of insect control whereby all that was required to create a new superstar was to tinker with the molecular structure of a vast variety of chemical compounds and create new and effective solutions to insect control problems. We were like kids with a magnificent collection of new Christmas toys. As with kids everywhere, we may have forgotten just a little bit, the true spirit of Christmas in the joy of new adventure.

The next 10 years saw us happily playing with our toys without much more than a passing thought now and then for the future. We applauded all successful control projects using methods other than chemicals, but insisted that the methods were too

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This article was adapted from the Presidential address presented by the author at the December 1969 meeting of the Hawaiian Entomological Society. The address was initially published in the *Proceedings*, Hawaiian Entomological Society, Vol. 20, No. 3, 1970.

uncertain and costly for extended use. We plunged along feeling secure and self-righteous even though we sometimes seemed to create two problems in the wake of solving one problem. We referred to this phenomenon as "job insurance."

Resistance and Residues

WE had some nagging doubts when the stupid insects began to develop resistance to the lethal effects of some of our pet chemicals, but we quickly told ourselves that we had more smarts than the bugs and laughed gleefully as we created a plethora of new chemicals to which the insects and mites were not resistant, at least for the time being. We entertained a few doubts when our chemists found lethal chemical residues in our soil years after application of these same chemicals, but we brushed that aside with a flurry of analytical activity proving that these chemicals were not absorbed by edible crops in sufficient amounts to harm anyone. We told stories on our rounds assuring folks that they would have to eat two bushels of apples a day to ingest enough DDT to be harmful at the tolerance set by our regulatory agencies. The folks laughed because of the well-known cliche of the apple a day keeping the doctor away.

We felt a true zeal akin to the early missionaries arriving in the brigantine Thaddeus on the shores of Hawaii. Why did we feel so self-righteous and smug? Why did we want to spread our superior knowledge and technology throughout the world? Why?

Of inescapable importance is the fact that we must eat food to stay alive. Despite our vast technocracy here in the United States, we have not yet found a technique of divorcing our bodies from the animal appetite for food, which we share with virtually all animals. Food is the one major element necessary for survival of an individual human. Food and reproduction are the two essential constants for species survival. When we reproduce, we immediately create a need for more food. Food, then, is the touchstone of human survival.

There was a time in human history when man selected his food on a chance basis. He would discard a rotten part and eat the good part. He was satisfied as a forager. Then he began to band together into permanent cities and towns for protection from his enemies. These cities and towns enlarged as man mastered his environment. At the time of the industrial revolution in the United States at the turn of the century, he had reached the point where he was capable of paying more attention to his creature comforts and foraging for food was a thing of the past. Food for the cities was produced on the farm and, as farm technology increased, each farmer was able to feed more and more of his city brethren.

Pressure on the Food Chain

AS city and urban populations, dedicated to the production of automobiles and a vast array of material goods, multiplied like a cancerous growth on the land, the farmer was left with the burden of feeding these helpless multitudes.

This, then, solves the phenomenal charisma of DDT and its fellow chemicals. The pressure on the food chain from farmer, to transporter, to wholesaler, to retailer and on to the consumer was crushing. In addition to producing the plain, raw food, the food had to be concomitantly absolutely perfect. Regulations were promulgated to insure that no insects or insect remains contaminated that food. The money would not pass from the hands of the consumer back through the chain to the farmer unless the product was of the highest quality. These are the economic facts of living today in the United States.

During the past 15 years, disturbing side effects from the use of DDT and some of its relatives have become exposed. The widespread usage which resulted in these side effects would have been impossible in the days of the horse and buggy. The airplane and the tractor are the culprits here. Vast acreages were treated in a matter of hours or days. The plague of locusts which since biblical times has caused the death of hundreds of thousands of human lives from starvation has been controlled by airplane treatments with dieldrin. Thousands upon thousands of human lives have been saved as a result of DDT applications to control insects vectors of decimating diseases. Man has protected millions of acres of forest lands with DDT applications so that he can preserve his source of basic shelter material and bury himself in tons upon tons of paper. This magnificent contribution to the welfare of man, DDT, is now under indictment for the key reason it came into widespread use. It is altogether

too persistent in our environment. It has poisoned our wildlife and the fish in our waters and is well on its way, along with a number of its persistent relatives, to being irrevocably banned from our environment. DDT is like a fascinating guest that simply stayed too long.

The same public which originally demanded the use of DDT and other chemicals to increase the production of high-quality food and fiber has now risen in righteous wrath at the mounting evidence of environmental pollution. The evidence of widespread environmental pollution is also available for the automobile, yet, at least at this time, most of us drive our automobiles to work and would become immeasurably irate if we were told that we could not drive, but would have to walk. Yet the death rate from auto accidents is 50,000 per year, 2 million persons are injured annually, and the estimated cost of motor vehicle accidents this year will exceed $8 billion.

Crossroad of Decision

SOCIETY, in the United States, is now at a crossroad of decision. Despite our general high standard of living, there are still serious pockets of famine in our land. Half of the rest of the people of the world are starving. Dire predictions of the doubling of our world population in a matter of 40 to 60 years as a result of the conquering of human diseases and other factors are periodically raised. The economic entomologist feels the firm pressures from these facts and concludes that he must work on increased food and fiber production to feed, clothe, and house this burgeoning world population. He also recognizes that at the present time, there is no other method of insect control as effective as chemical control for this purpose. This is a sobering fact.

Obversely, a horrendous cry is raised and increasingly restrictive legislation is being promulgated to protect the environments of the world from the world's most active polluter and despoiler—the human species and his multitudinous activities. Since 1492, less than 500 years ago, the human species has simply overrun the world. Society looks around at its fouled nest and howls "This must stop." We must ban persistent pesticides from our environment along with cars, factories, airplanes and other pollutants. The economic entomologist is also sensitive to this pressure and concludes he must work on insect control measures which do not harm the environment. Since, at the present time, it would be impossible to produce the amount of high quality food consumed by the population of the world today without chemicals, a feeling of hopelessness ensues, since, despite the public outcry, the public still hasn't caught up with the fact that instead of spending billions of dollars to explore the moon, those billions of dollars are needed to expand the volume of research necessary to produce an adequate amount of food and fiber, without chemical pollutants.

Simply as an exercise in perspective, let us see if we can find an answer to this dilemma by treating a colony of human beings with the same scientific detachment with which we would explore solutions to problems in a colony of mice or a herd of cattle. Let's go along with the astronauts to the moon and look back on earth from that distance. We might dream up these recommendations.

1. It seems obvious that if the world is bulging at the seams with such a large herd of animals that it is outstripping its food supply, there should be some form of population control instituted.

2. It seems equally obvious that the population is fouling its environment and the industries that produce pollutants will have to go, including those that produce pesticides, paints, and plastics, as well as automobiles and gasoline; in other words, virtually all the toys this population is used to playing with.

3. The population has to be dispersed from huddling together in what they call cities and everyone will have to return to producing his own food. In this way, everyone will have more time to fight insects and other pests.

4. We'll have to recommend instituting a breeding program so that the herd can raise a new breed of individuals with a thick fur covering, making clothes and houses unnecessary.

Seriously, though, coming back to earth and our society in which we have to live, which direction can the economic entomologist take and still stay within the parameters of public pressure? If we go in the direction of eliminating chemical control, we have to bear in mind that monumental sums of money are necessary to implement these programs to attain the same degree of efficiency now available with chemical poison control methods.

We also have to bear firmly in mind that man's battle with insects is strictly from the point of view of man and not what we can euphemistically call nature. A mosquito is useful in nature as food for birds and insects. To man it is a menace to his well-being and health. A termite in nature is one of many useful organisms in the forest economy which break down solid matter (namely wood) into organic matter useful to other organisms. To man, a termite is a menace to his costly home.

The Manipulation Approach

PRECISELY what do we do when we "control" insects? One definition is given in a recent magazine cartoon depicting a pest control man kneeling on the kitchen floor with a whip in his hand. A neat array of marching cockroaches with flags flying are distributed around the floor in martial array. The woman of the house is looking on, astonished. The pest control man says, "We don't kill them, lady, we just control them."

Think about that just a little bit: "We just control them." Another way of saying it would be, "We just manipulate them." Manipulation of insect population is basically the only sound, constructive approach to suppression of insect populations. The reason for this is simple. Contrary to the beliefs of religious fanatics, there is a biological force in the world which is just as interested in the survival of the insect as it is in the survival of the human. We have to use our brains and our technology to live *with* insects. We will never, never, annihilate them from the face of the earth without annihilating ourselves as well.

Economic entomologists have known this secret for many years. We have been deficient in not letting the public know about it. When someone calls in and asks about ridding their house of cockroaches, we have said: "Use chemicals; it is the simplest and the cheapest method of suppression." Since the public accepted this answer without much question, it was the easy way out and forestalled a lot of detailed and time-consuming conversation.

Now we are going to have to educate the public, and the governments established by the public, that our latent and somewhat dormant concept of insect population management has to be generated and charged with a force of an Apollo mission. To manage insect populations, instead of simply trying to kill off comparative thimblefulls in terms of the total population, we need sophisticated computers and many thousands of additional investigators, computer-feeders, data gatherers, and computer data analyzers to get the job done. The reason for this is that it would be exceptional to find only one species of insect in a given ecosystem. Take an average home for instance. There might be termites, cockroaches, ants, fleas, ticks, pantry pests, bed bugs, carpet beetles, house flies, mosquitoes and finally, bird mites crawling all over everyone and driving them wild because they cannot be seen. Each one of these human pests needs to be suppressed, managed, or manipulated in some way. In the case of bird mites, simply removing the bird nest giving rise to the mites will suffice. In the case of fleas, remove the dog or cat and make someone very unhappy. You see, it is not simple.

We are developing along many lines to reduce the need for chemicals in our insect population management programs. These include chemosterilants, sex attractants, use of juvenile and other hormones, irradition sterilants, energy waves of various kinds, and biological organisms harmless to man but harmful to insects. We are also looking over

all our old methods of control—some of which have been discarded for economic reasons—such as crop rotation, mechanical controls such as screens and fly swatters, cleaning up of food media, and many, many others. The list is almost endless in both categories.

Successful use of all of these manipulation and management techniques, as opposed to simply spraying a chemical around in an attempt to kill insects outright, requires a much broader and more sophisticated program than we have seen up to now. It is going to require a much more extensive public education program backed up by much more research than we have seen up to now. It is also going to be much more expensive and, in some cases, may be downright traumatic. As an example, we have available at this moment an effective cockroach control program which does not require the use of a gram of chemicals. This is simply the encouragement in our homes of the emerald cockroach wasp, the ensign cockroach wasp and the wolf spider. These three organisms are perfectly capable of completely cleaning up a population of cockroaches in any home. But, our phobias and hangups get in our way. We don't want anything in our homes that creeps or crawls. We are afflicted with *entomophobia.*

Without chemical control we may occasionally find a worm in our salad. Strictly speaking, from a purely scientific point of view, there is absolutely nothing wrong with eating a worm or two along with our salad. From the pure standpoint of edibility and nutrition, a worm is edible. However, our entomophobia makes it impossible for us to consider that worm as food fit for human consumption and we consider a human society which dines on insects as primitive and uneducated and much beneath our consideration. Hence, our dedication as a society in the past to sanction and foster methods of insect suppression aimed at complete destruction of an insect population which dares to do what comes naturally and feed upon our salad greens. Chemical control has been by far the most effective, the most popular, and the cheapest method of accomplishing this aim.

Increased Human Welfare

In conclusion, I submit as an economic entomologist, that I know perfectly well that we have been polluting our environment with pesticides. For that matter, so has everyone else with their products of our advanced civilization. We have also done everything in our power to minimize and eliminate the detrimental effects to man in the use of such pesticides. We also are aware of the many other pollutants in our environment and strongly urge a concerted and intelligent approach, now, to the problems of pollution.

But, we also look around us and see that we are human beings and are vulnerable to human feelings. As a society, there are many, many things we are unable to give up that cause pollution. To just single out one, all we need to do is reflect on our gasoline-powered automobiles for a short time and you can readily see my point.

Economic entomologists are just one of the many thousands of groups charged with the responsibility of feeding the 3 billion people on the face of the earth. We also assist in increasing the population of the earth through reducing and eliminating diseases, providing materials for improved shelter, and providing for recreation and other needs.

The involvement of the economic entomologist with society is intimate and dedicated. We have a job to do and we are going to direct our best efforts toward the basic goal of increased human welfare. We are going to need more cooperation than ever before from allied groups including ecologists, biologists, economists, conservationists, nutritionists and home economists. We need the help from nutritionists and home economists in case we fail in our objective. If we fail, we'll need information on the nutritional value of insects and other arthropods, and my wife and I will invite everyone over to our house for grasshopper sandwiches.

SCIENCE NOTES

ERGONOMICS

ERGONOMICS, an emerging discipline described as a new way of looking at the relationship between man and his work, was the subject of a symposium recently held in Rome, Italy. Development of the new discipline is a direct outgrowth of social problems unique to modern times: Mankind appears to have accepted its own transference into an abnormal dimension where knowledge is subject to impassable limits and creative effort has no place. In other words, man seems to be passively suffering the "civilization of the machine."

One research approach to the problem is the study of man's reactions to the following environmental factors: mechanical vibrations, noise, electromagnetic radiations, odors, lighting, and climatic conditions. Despite the newness of ergonomics, the symposium proceedings reveal a considerable storehouse of knowledge already documented. These findings, hopefully, may provide the means for society to "interpret the needs of man, not as a chopping-block, a mere tool, but as the industrious craftsman, the intelligent protagonist of his world and his age."

The Sahara Desert is spreading southward along a front 2,500 miles long, at a rate of 3 feet a year, and is threatening the agricultural resource of the African country of Mali.

NEW JAPANESE BROILER

A new chicken has appeared on Japanese markets. Called the *buroira* (a corruption of broiler), it lives in an environment totally devoted to the production of meat. It's a force-fed fowl raised in a tiny cage in which it cannot walk, flap its wings, or scratch for food. The buroira resembles certain U.S. breeds, and is made to grow faster by lighting the coops 24 hours a day, and by feeding a mixture that includes cyclamates, chemical tranquilizers, laxatives, hormones, antibiotics, and about a dozen different nutritional acids. Although none of the feed ingredients are considered harmful to man in the doses given, there has been some concern in Japan over the antibiotics, which can foster resistant strains of bacteria, and the hormones, which can cause enlargement of mammary glands.—*Atlas* 20:8.

Wildlife specialists are experimenting with artificial insemination and embryo transplants as a way to prevent disappearance of endangered species of wildlife.

NEW USE FOR SAWDUST?

Twenty Holstein milk cows at the Wisconsin Agcultural Experiment Station have been chewing cuds that were liberally seasoned with sawdust from aspen trees. Purpose of the research is to find a substitute for hay as roughage in hay-short areas and to develop a use for wood waste.

The hammermilled sawdust was combined with feed concentrates in pellet form. Tests show that 32 percent sawdust in the concentrate could partially replace hay and maintain good milk and butterfat production. Although aspen is one of the most digestible of woods, further tests are being made to increase its digestibility by chemical treatment.—*Wisconsin Science Report,* No. 601.

Pumping thermal discharge into a catfish pond provides such a favorable environment that the stocking rate of 6-inch catfish fingerlings can be raised from 2,000 per acre to as many as 50,000 per acre.

MAIZE CIRCLES THE GLOBE

As demands for cereal grain production increase and maize plantings further encircle the globe, the work arena of the International Maize and Wheat Improvement Center (that's Nobel Prize winner Norman Borlaug's agency) has expanded to keep pace. Reports show: a record maize yield in Thailand, a 30 percent increase in West Pakistan, a 40 percent acreage boost in India, and a maize surplus situation in Kenya. The Center and the United Nations Development Program are now spearheading a worldwide cooperative effort to develop high protein varieties of maize. Of S_1 families in 19 populations, more than half show promise as a source for new high-lysine mutants.—*CIMMYT Annual Report.*

From 1940 to 1969, 27.8 million Americans moved off the farm and into the city—a movement outranking even the massive European immigration that brought 22.3 million people to the United States in the 40-year period, 1890 to 1930.

SYNTHETIC ANTIGENS

The Canadian National Research Council has announced the development of new chemical methods for preparing synthetic antigens—substances that stimulate the production of antibodies. By this means, a compound that is not by itself antigenic can be joined to an antigenic carrier molecule. Subsequent injection of the conjugate into an animal induces the formation of antibodies specific for both parts of the conjugate. It is therefore possible to make synthetic antigens using only a specific determinant group and an antigenic carrier.

Practical exploitation of this development requires the isolation of the specific antigen from disease-causing micro-organisms and characterization of their determinant groups. This work is a prime example of the interdisciplinary approach to research that is essential for major advances in the life sciences, because it has required close collaboration of bacteriologists with facilities to grow highly dangerous microorganisms, and of chemists and biochemists with experience in immunology.—*Report of the President, Canadian NRC, 1971.*

SCIENCE PREDICTIONS

The maturity of a science can often be judged by the precision with which successful predictions can be made. Given the appropriate initial conditions, how will a given system evolve or develop with time? Man's success in some forms of predicting has been uncannily accurate, as, for example, plotting the path of a moon rocket or the orbit of a planet. But in other areas, we're not doing very well.

For instance, in many situations it is not possible to predict in any definitive manner:

- The transport of pesticides, pollens, and other airborne particles, nor the long-term chronic effects of contaminants.
- The occurrence of earthquakes and volcanic eruptions, nor how an electric charge separates in clouds and forms lightning.
- The long-term climatic effects of carbon dioxide, heat, or particulate matter introduced into the atmosphere.
- The movements of currents in lakes and oceans, nor the transport or destination of wastes dumped into them.

What is the reason for this discrepancy? The answer is that in some sciences, prediction is impossible either for practical reasons, related to complexity, or because of the inherently statistical or random nature of the phenomena being studied. In contrast, when we plot and predict the path of an Apollo spaceship, we rely almost solely on Newton's laws and the universal law of gravitation. Whether we can improve our ability to predict more successfully in other sciences, particularly the environmental sciences, will depend largely on the acquisition of more quantitative information rather than qualitative.—*1971 Report, National Science Board.*

The social structure, or peck order, in a flock of chickens can be easily detected by observing their posture stances. Subordinate birds keep their heads lower than their dominant neighbors. If a hen forgets and raises her head higher than her status permits, she is immediately "put in her place" with either a vocal order or a reminder peck.

BOOK
REVIEW

The Human Factor in Agricultural Development

From Peasant To Farmer: A Revolutionary Strategy for Development, Raanan Weitz, Columbia University Press, N.Y., 292 pp. 1971. $10.

AGRICULTURAL experts from affluent nations have had to learn the hard way that exporting technology to less-developed countries can be a frustrating experience if they neglect to consider the human factor of the people they are trying to help—in other words their customs, fears, beliefs, and traditions. Now, for the first time, an entire book has been written on this extremely important aspect of agricultural development.

The author's no-nonsense convictions appearing in the preface leave no doubt in the reader's mind as to what course the book will follow.

"The difficulty is," he explains, "that an understanding of—and even more important, a feeling for—the fate of the 'little man' tends to become an abstraction in the usual schedule of government officials in the distant capital. This state of affairs cannot continue for long."

He goes on: "This book is based on the assumption that in the coming decade policymakers will be seeking practical answers and concrete solutions to the problems of rural development and that they will not be deterred from applying measures that may conflict with the narrow, short-term interests of small power groups. This book is written mainly for them."

Dr. Weitz is on the staff of the National and University Institute of Agriculture, Rehovot, Israel. His book is the result of a five-year study commissioned by the Twentieth Century Fund, and is based in part on field work he and a team of specialists carried out in Ceylon, Greece, Spain, Turkey, Mexico, and Israel.

He describes the kind of changes required for increased agricultural growth and indicates how they can be best carried out. He also points out how to accomplish needed adjustments in backward rural communities so that they can take advantage of technological advances.

Far from ignoring industry, Dr. Weitz believes that its development must be encouraged. He is convinced that agriculture and industry are intertwined and stresses that industrial growth "is essential not only for the growth of the national economy but for the advancement of agriculture itself."

The book ends with a delightful anecdote illustrating Dr. Weitz' belief in the importance of the human factor in successful agriculture development. While visiting a development area one summer, he wanted to find out why the peasants refused to grow a new cereal that, in the opinion of experts, would improve the economic situation of the area.

The director of the development authority drove him out to the area where the peasants were working in muddy, rain-soaked fields. The director started shouting to the peasants to leave their ploughs and come over to the car. Weitz objected. "Let's go to them," he suggested. Whereupon, he took off his shoes, rolled up his trousers, and started walking through the mud. Reluctantly, the director followed suit.

They had a long chat with the peasants. After they returned to the car, rinsed the mud off their feet, and continued on their way, the director—after a thoughtful silence—said: "In one conversation you managed to find out things that my men failed to discover after weeks of talks and surveys. Why?

Dr. Weitz smiled. "It is because we rolled up our trousers."

THE AUTHORS

J. J. CALLIS ("Plum Island Laboratory—Its Role in Foreign Animal Disease Research") is Director, Plum Island Animal Disease Laboratory, ARS, U.S. Department of Agriculture, Greenport, L.I., N.Y. He received his D.V.M. degree from Alabama Polytechnic Institute and an M.S. from Purdue University. From 1949 to 1951 he worked in the State Veterinary Virus Research Institute of Holland. During 1952 he was a research veterinarian at the USDA Animal Disease Station at Beltsville, Md. Dr. Callis has been on the staff of Plum Island Laboratory ever since it was established—first as chief of research operations, and later becoming assistant director in 1956 and director in 1963. He received the USDA superior service award in 1957 and the William A. Jump meritorious award for exemplary achievement in public administration in 1963. Dr. Callis has developed an international reputation for his knowledge of exotic animal diseases.

E. E. SAULMON ("When FMD Strikes") is deputy administrator for veterinary services, Agricultural Research Service, USDA. After graduating from the College of Veterinary Medicine, Ohio State University, he joined the Department's Bureau of Animal Industry in Kentucky, later moving to the Mexican FMD eradication program where he served in progressively responsible positions. He joined the Washington staff in 1956 as assistant to the director, Animal Disease Eradication Division, and in 1961 was named associate director. After serving a 2-year term as Deputy Director, Science and Education, he returned to the Animal Health Division as Director, and in 1970 he was appointed to his present position. Dr. Saulmon has represented the Department of Agriculture on a number of foreign assignments in Europe and the Far East on animal disease problems.

SYLVAN H. WITTWER ("International Involvement") is Director, Michigan Agricultural Experiment Station and Assistant Dean of Agriculture, Michigan State University. He earned his B.S. degree at Utah State College and his Ph. D. at the University of Missouri. He joined the Michigan staff in 1946 as assistant professor of horticulture and was appointed to his present position in 1965. He has published more than 300 papers and scientific reports in his field of horticulture, plant physiology, and agricultural technology, and co-authored a book, *Greenhouse Tomatoes: Guidelines for Successful Production*. Dr. Wittwer has received national recognition in many aspects of horticultural science and has been the recipient of numerous awards, including the first Campbell award of AAAS and the MSU Distinguished Faculty award. He has been particularly active for more than a decade in international agricultural activities, and has served as consultant to the United Nations Development Program and a number of foreign countries.

BOYSIE E. DAY ("Science Decision Models") is associate director, California Agricultural Experiment Station, Berkeley, Calif. He received his B.S. and M.S. degrees from the University of Arizona and his Ph. D. from the University of California. In 1950 he became professor of plant physiology at Riverside, Calif., and in 1966 was appointed chairman of the Horticulture Science Department and served in that position until his present appointment in 1968. Dr. Day has been active in several science discipline associations, AAAS, Weed Science Society of America, and the Society of Horticultural Science.

WILLIAM R. NELSON, JR. ("Human Happiness and Welfare") is associate professor and Extension landscape architect, University of Illinois. He received his degree in landscape architecture from Washington State University in 1955. Prior to joining the Illinois staff in 1959, he was associated with the Spokane (Wash.) Park Department. He has been particularly active in developing programs of landscape architectural design for rural and urban development and beautification, and is presently involved in a study on the design of a therapeutic environment for the mentally retarded. Among his many credits, Professor Nelson is author of the book, *Landscaping Your Home*, and producer of the film, *A Place To Be Human.*

ESTHER L. BROWN ("Human Happiness and Welfare") is associate professor of nutrition, Dept. of Home Economics, University of Illinois, Urbana. A graduate of Iowa State University, she received a master's degree in public health nutrition from the University of Michigan and a Ph. D. in nutrition from Michigan State University. She has taught home economics in secondary schools and served as a consultant to the Michigan Department of Health and the National Dairy Council. Dr. Brown joined the Illinois staff in 1963. Her research interests include nutrition education and calcium-phosphorus interrelationships in bone disease.

A. A. LAPLANTE, JR. ("Food, Fiber and the Economics of Entomology") is an economic entomologist, University of Hawaii, Honolulu, Hawaii. He received his B.S. degree from Massachusetts State College and his Ph. D. from Cornell University. He began his career as assistant extension entomologist with the Pennsylvania State University. In 1949 he joined the staff of Cornell University as extension entomologist and worked in that capacity for 7 years. Dr. LaPlante worked for the Government of Guam as an entomologist and chief agriculturist from 1957 to 1964. In 1964 he became professor of agriculture at the College of Guam and served in that position until his present appointment in 1965.

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